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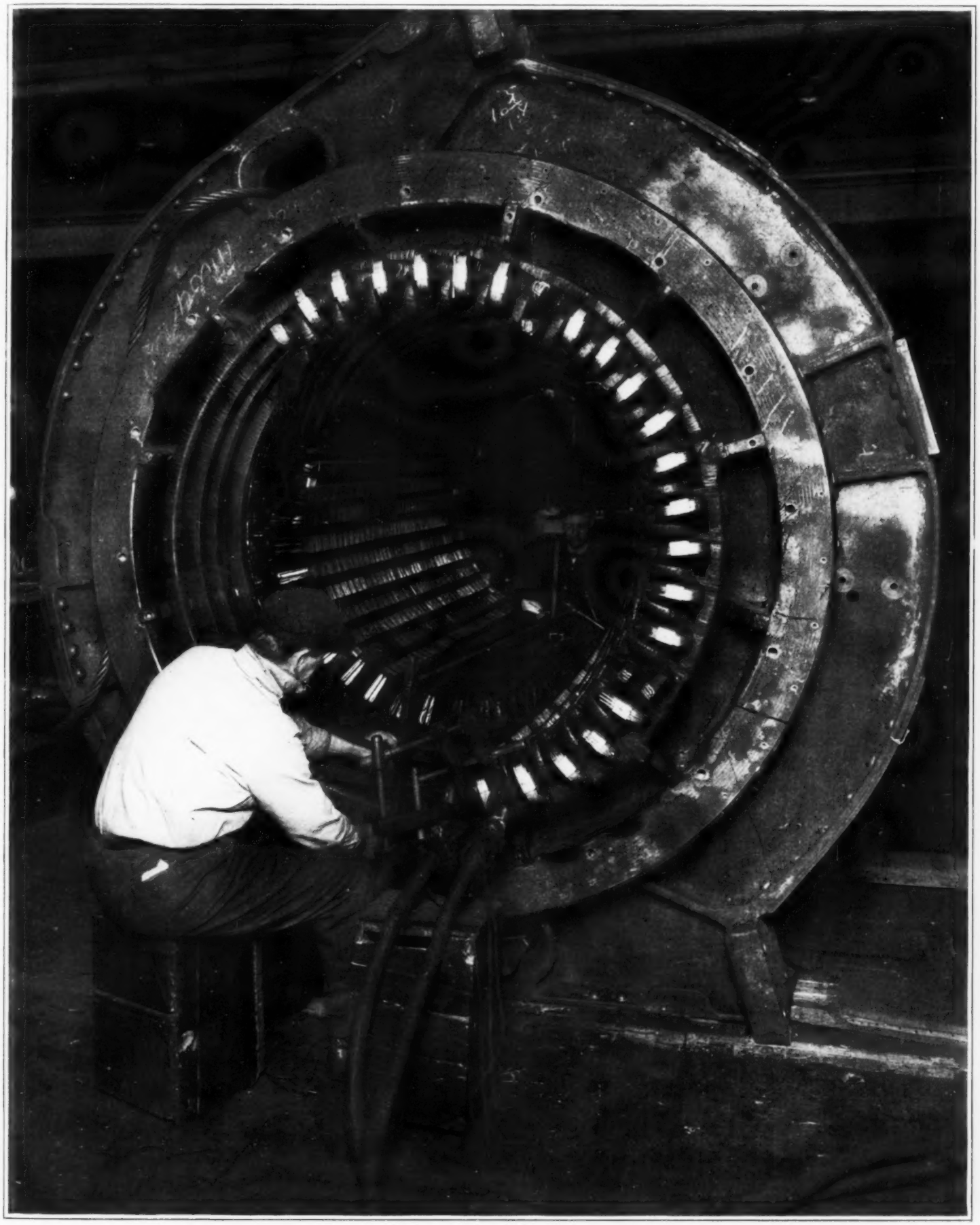


Assembling the coils of the stator in the turbine-generator

ELECTRIC PROPULSION FOR THE U.S.S. NEW MEXICO [See page 356]

Electricity and Matter*

The Major Points in the Case for the Electron

As the result of exhaustive researches, which have now extended over a period of at least thirty-six years, physicists have been forced to the conclusion that electricity is atomic in structure, and the confidence with which they hold to this deduction is not much removed from that reposed in the doctrine of the impossibility of a successful perpetual-motion machine. While, however, the results of the numerous careful investigations made during the past few years are conclusive to those who have studied them, there are many engineers who, in the press of their other engagements, have been unable to follow the progress of these researches, and it may accordingly be of interest to our readers to have a summary of some of the simpler arguments adduced in favor of the hypothesis.

It has long been known that in such an operation as electro-plating the weight of metal deposited is directly proportional to the quantity of electricity passed through the bath, and in 1834 Faraday proved that in the case of metals having the same chemical valency the weight of each deposited by the passage of a stated quantity of electricity was exactly proportional to the respective atomic weights. Thus the passage of 96,500 coulombs will deposit 39.1 grammes of potassium or 23 grammes of sodium, while with divalent metals twice as much electricity will be required to deposit a weight equal to the atomic weight in grammes, and with trivalent metals three times as much; so that to deposit 27 grammes of aluminium the quantity of electricity required will be $3 \times 96{,}500$ coulombs. These experimental results are most simply co-ordinated if it be assumed that electricity has an atomic structure, and that each atom of a monovalent metal carries with it in electrolysis one atom of electricity, each divalent atom two atoms of electricity, and each trivalent atom three atoms of electricity.[1] This suggestion was definitely made by Helmholtz, in 1881, though we believe it originated earlier, and the name electron was coined for this atom of electricity by the late G. Johnstone Stoney.

The evidence in favor of the above view has since been considerably strengthened, because metallic ions have been obtained in the vacuum tube. In this case the ions of the metal move with great velocities in straight lines, and when they strike against a photographic plate affect it so that, on development, a black patch appears at the point of impact. By placing in the path of these ions a screen having an extremely small hole in it, only a very small pencil of these moving ions is able to reach the photographic plate. It is found by experiment that if this pencil be caused to traverse intense magnetic and electric fields, it is deflected. The slower moving atoms are deflected most by the electric force since they are longest exposed to it, while, on the other hand, the magnetic force exerted on the ion increases with the velocity of the latter. The result is that a curve and not a spot appears on the plate when this is developed. The amount of deflection depends, however, not merely on the velocity of the particle, but also on the charge carried by it. If this charge varied continuously from atom to atom, a brush rather than a well-defined curve would, in all cases, be shown by the photographic plate after development. It turns out, however, that by suitable precautions a curve as sharp and clearly defined as a hair can be obtained. Cases arise in which some of the ions carry more than one charge, but the result on the plate is two or more distinct and sharply defined curves. There is no indication of any continuous variation of the charge from atom to atom. Each atom carries, say, either one, two, or three unit charges; never one and a quarter charges, or two and seven-eighths of a charge. Hence it is a reasonable conclusion that the results observed in electrolysis are not merely obtained by averaging a number of charges varying from atom to atom, but that here also each atom carries, say, one, two or three unit charges of electricity, and never a fraction of these amounts. The laws of electrolysis thus afford cogent evidence in favor of the atomic nature of electricity.

Another kind of research which led to the same result, was originated by Crookes, who in the course of experiments on vacuum tubes was driven to the conclusion that the rays observed in such tubes at high vacua consisted of a stream of little electrified particles, and he was pretty sure that these particles were not particles of ordinary matter. For them he coined the name "radiant matter." These rays shot out, he found, in straight lines from the cathode, causing phosphorescence of the glass of the tube where they struck it. An obstacle placed in their path cast a sharp shadow. This view of Crookes, which is now universally accepted, was sharply criticised at the time, particularly in Germany, where it was held that the rays were essentially a disturbance in the luminiferous ether, and with some air of triumph the German experimenters demonstrated that the rays could pass through thin sheets of aluminium, a discovery which they held to be conclusive evidence of the falsity of Crookes' hypothesis that the rays consisted of electrified particles. This reasoning would have been more decisive if Crookes had claimed that his particles were ordinary gaseous particles. If they were much smaller than these there was no reason why they should not be able to penetrate through the interstices between the molecules of the aluminium, although these were impervious to air or other gases.

Crookes had shown, moreover, that the rays, whatever they were, were easily deviated by a magnet, which has no similar action on light. Moreover, the rays could not be diffracted, as light would be, an argument the force of which is enhanced by the later discovery that the Röntgen rays, which are generated when the cathode rays impinge on a metallic target, can be made to yield diffraction patterns, proving them to be a form of light with extremely small but perfectly determinate wave-lengths. These Röntgen rays are not deviated by a magnet, and hence it is, to say the least, extremely improbable that the cathode rays have a similar character. Moreover, the cathode rays, if concentrated on a target, can raise the temperature of the point of impact to such an extent as to fuse the surface of the most refractory metal, acting in this respect exactly as if they were a stream of projectiles.

Again, both theory and experiment have shown that a rapidly moving particle charged with electricity would be acted on by a magnet exactly as an equivalent continuous current of electricity would be, so that the behavior of the cathode rays in regard to a magnet is what would be expected were they a stream of charged particles. That they do carry a charge was proved by directing them into a hollow metallic receiver connected to an electroscope, which showed that the receiver acquired a negative charge of electricity.

While, however, the evidence was conclusive that these rays were actually a stream of electrified particles, there was no direct evidence as to the precise nature of these particles. They might conceivably be atoms or molecules of a gas, though Crookes had been forced to a contrary conclusion, and the fact that the rays would pass through a thin sheet of aluminium was strong evidence that the particles, whatever they were, were of finer structure than ordinary atoms or molecules.

The corpuscles constituting the cathode rays were, as stated, found to be deflected under magnetic forces. They were also, at a much later date, proved to be deflected on passing through an electric field produced by two parallel plates coupled to opposite poles of a battery. Astronomers determine the masses of the stars by observing their deflections in the gravitational field of force due to their mutual attractions. The problem in the case of the corpuscle was more complicated. The deflection of a particle passing between oppositely charged plates will be greater the greater the charge carried per unit of mass, since the deviating force acting is proportional to the quantity of electricity, and the inertia or reluctance to motion of the particle is measured by its mass. This deflection will obviously be greater the greater the time during which the deviating force acts; that is to say, the greater the time taken to pass between the oppositely electrified plates. This time is, of course, inversely proportional to the speed of particle, and hence, if this were known, the amount of electricity carried per unit of mass could be calculated from the observed deflection, just as Newton calculated the force per unit of mass acting on the moon from its observed deviation from the tangent to its path.

The fact that the cathode rays were deflected also by the magnetic field and according to a different law than that deviating them in an electric field made it possible to determine their speed. The problem, it will be seen, contained two unknown quantities, viz., the charge carried per unit of mass, which is denoted by $\frac{e}{m}$, and the speed of motion v. The deflection in the electric field gave one equation between these two unknown quantities, and that in the magnetic field another. Solving these two simultaneous equations both $\frac{e}{m}$ and v were determined. The experiments have been made and remade again and again, with great care, and have shown conclusively that in the case of cathode rays the charge carried per unit of mass is some 1,700 times as great as is carried by a unit mass of hydrogen in electrolysis. Hence either the charge e is 1,700 times as great as the charge of the hydrogen atom in electrolysis or the mass of the corpuscle is only $\frac{1}{1700}$ that of the hydrogen atom.

Further experiment showed that similar electrified particles having the same ratio $\frac{e}{m}$ were obtainable in many other ways, as well as in the form of cathode rays. The electricity liberated when ultra-violet light is directed on to a zinc plate was found to be similarly constituted; the carriers, whatever they were, having the same ratio $\frac{e}{m}$. In this case the particles move but slowly, and such slowly-moving particles are found to attach themselves to the molecules of any gas in which they may be liberated. This fact provided a means of determining the value of e, and since the ratio $\frac{e}{m}$ was already known, the value of e gave that of m. The plan adopted depended on an exceedingly curious fact established by Aitken, viz., that in dust-free air moisture will not separate out as mist or raindrops, even though the air be highly supersaturated. Thus in one experiment exhibited at a meeting of the Royal Society of Edinburgh, in 1880, steam from a boiler was led into two equal glass globes, one filled with the ordinary air of the room and the other with air which had been carefully filtered and was dust-free. On turning on the steam the one globe filled instantly with a dense cloud, while in the other not a trace was to be seen. The explanation given by Lord Kelvin is based on the fact that the surface film of every liquid is in a state of tension, and to this "surface tension" all capillary phenomena are due. Hence work must be done to increase the surface of a liquid, and, correspondingly, such a surface constitutes a store of energy. This energy is directly proportional to the extent of the surface, and hence, in the case of a drop of water, its amount is proportional to the square of the radius. On the other hand, the supply of energy needed to evaporate a drop of water varies with its weight; that is to say, as the cube of the radius. Hence, by taking the radius small enough, the store of energy in its surface film becomes more than is required to evaporate the drop, so that a very minute drop of water, if it can be formed in any way, evaporates automatically.

It is found that a soap bubble will increase in size if electrified, the surface tension being partially balanced by the electric forces called into play, and thus the work available by letting the electrified bubble contract is correspondingly reduced. Hence it was thought that particles too small in the normal state to permit of water condensing on them to form mist might act as condensation nuclei if they were electrified, and this proved to be the case.

Dust-free air supersaturated with moisture was found to remain quite clear; while if corpuscles were liberated in it by, say, the action of ultra-violet light on zinc a fine mist appeared at once. The weight of the droplets thus formed could be measured by observing the rate at which they fell through still air, while the charge each carried could then be measured by subjecting them to the action of an electric field, tending to drive up against gravity the charge and the droplet carrying it. The electric force acting on the drop was proportional to the charge carried, and the force dragging it down to the weight of the drop. By balancing the two the electric force was determined, giving at once the value of the charge carried. Experiments based on this principle have now been made with great precision, and have shown that the charge carried is in all cases 4.774×10^{-10} electrostatic units of electricity, and is thus equal in numerical value to that carried by the hydrogen atom in electrolysis. Hence the value of m is $\frac{1}{1700}$ that of the mass of the hydrogen atom. How much of this corpuscular mass is ordinary gravitational mass is another question.

The conception that the apparent mass of a body may be much greater than that due to its weight is of course, not new, having long been familiar to naval architects. Mass simply measures resistance to accelerations, and the inertia of a body immersed in a fluid, even if this be

*From *Engineering*.

[1] Strictly speaking, as the electron is a negative particle it would be more precise to say that a monovalent metallic ion has lost one atom of electricity, while a divalent ion has lost two, but the argument is of course quite independent of the sign of the charge.

ideally perfect, is much greater than that due to the mere weight of the body. Experiments indicate that in the case of the cathode ray there is little, if any, ordinary gravitational inertia, and point to the conclusion that these rays are disembodied atoms of electricity, rent from their usual resting-place on atoms of matter.

Experiments in another field, that of spectroscopy, lead to quite similar conclusions. Zeeman found that certain spectral lines when exposed to the magnetic field became triplets. Accurate measurements of the distances between these components showed that they would be accounted for if the original single line of the spectrum was due to the motion within the atom of electrons similar in every regard to those believed to constitute the cathode rays.

Summing up, it will be seen that a very large variety of independent experimental data is co-ordinated if electricity has an atomic structure; that the most delicate experiments have shown that the charge carried by individual atoms is always a multiple of a certain unit, increasing not contnuously but by sudden jumps—a fact easily intelligible if electricity is atomic in structure; and that, moreover, it has been possible to make direct and precise measurements of the size of this atom. The only known criterion of the truth of a scientific theory is "Does it work?" and the evidence accumulated since Sir J. J. Thomson demonstrated some twenty years ago the true nature of the cathode rays has shown that the theory that electricity is atomic in structure "works" most satisfactorily in the most diverse fields, covering every department of experimental physics.

On Nucleic Acid and Its Analytical Examination*

By A. C. Chapman, F.I.C.

DURING recent years nucleic acid and certain of the metallic nucleates have found somewhat wide and increasing application in medicine, and particularly in connection with surgical practice. At the outbreak of war these substances were obtained chiefly from Germany and America, and so far as I am aware were not manufactured at all in this country. A number of urgent inquiries having been received from France and elsewhere, the Pharmo-Chemical Products Company, Ltd., suggested to me that I should undertake the investigation of this matter with the object of devising methods for the manufacture of pure nucleic acid and its derivatives on a large scale. Yeast was obviously the most convenient raw material, and for more than a year considerable quantities of pure yeast-nucleic acid and its compounds have been manufactured.

It will be obvious that, in the prosecution of this work, it was necessary to have methods for examining the products obtained and to establish analytical *criteria* of purity. The production of pure nucleic acid on a large scale presents many difficulties, the two chief ones being the complete removal of protein and the prevention of the contamination of the acid with the products of its own decomposition. This will be at once apparent when it is remembered that nucleic acid results from the breaking down of the nucleo-proteins of the cell nuclei on the one hand, and that, on the other, it yields, as the result of further hydrolytic change, a number of complex nucleosides and bases, together with phosphoric acid and the carbohydrate *d*-ribose. The conditions for hydrolysis have therefore to be very exactly determined and very strictly observed in practice.

Up to the present two nucleic acids have been very fully studied, the one derived from yeast, the other from the thymus gland. Whether these two acids represent typical members of two sharply defined groups, or whether all nucleic acids are identical with one or the other, is at present a little doubtful. The latter view is, however, the one more generally held, and the nucleic acid from yeast is frequently known by the more comprehensive term "plant-nucleic acid." It is with this plant nucleic acid that the present paper chiefly deals.

The following statement shows at a glance the chief products of hydrolysis of these two nucleic acids, and at the same time affords an insight into their respective chemical constitutions:

Plant Origin.—Guanine, adenine, cytosine, uracil, *d*-ribose (pentoose), phosphoric acid.

Animal Origin.—Guanine, adenine, cytosine, thymine, lævulinic acid (from a hexose), phosphoric acid.

Plant nucleic acid is a white friable substance devoid of odor or taste, and having the formula $C_{35}H_{50}O_{28}N_{15}P_4$. It is practically insoluble in water, but dissolves readily in solutions of alkaline acetates. It is also readily soluble in solutions of the alkalis forming the soluble alkaline salts. From these solutions a few drops of hydrochloric acid precipitate the nucleic acid in a dense curdy form, which dissolves completely on the addition of a large excess of the acid.

*From *Chemical News* after *The Analyst*.

When acetic acid is added to a solution of the sodium salt the acid is partly precipitated, but no precipitate is formed on the addition of any acid in the presence of a sufficient quantity of alkaline acetate.

When added to a solution of sodium nucleate a solution of copper acetate acidified with acetic acid gives a bulky greenish blue precipitate.

Calcium chloride in excess in the presence of a few drops of acetic acid gives a white precipitate at first flocculent, quickly becoming more granular.

Silver nitrate, when added in considerable excess to a fairly strong and neutral solution of sodium nucleate, gives a white gelatinous precipitate. On the addition of a little sodium chloride this dissolves, forming an opaque colloidal solution. One drop of hydrochloric acid added to this precipitates the silver as chloride.

Solutions of sodium nucleate in water exhibit a marked tendency to gelatinise, and, if sufficiently strong, set to a jelly.

For the hydrolysis of nucleic acid 10 grms. of the acid (or a larger quantity if available) are heated in a boiling water-bath for two hours with 40 cc. of 10 per cent sulphuric acid (or a proportionately larger quantity if more than 10 grms. are taken) in a small flask fitted with an air condenser. At the end of this time strong ammonia is added to the hot solution in the flask until the liquid contains an excess of about 2 per cent. The guanine is precipitated in a granular form, the adenine remaining in solution. After filtering and washing with 1 per cent. ammonia the guanine is dissolved in the smallest possible quantity of dilute sulphuric acid, decolorised if necessary by means of a little animal charcoal, and the base precipitated again from the colorless solution by the addition of an excess of ammonia. The purified base may then be converted into the hydrochloride, which crystallises very readily and may be easily identified by the application of any of the well known tests. The ammoniacal filtrate from the guanine, together with the ammoniacal washings, is acidified with sulphuric acid, heated to boiling, and the adenine precipitated as a cuprous compound by the addition of a 10 per cent. solution of copper sulphate. Inasmuch as the solution contains the carbohydrate ribose it is not necessary to add sodium bisulphite for the purpose of reducing the cupric compound. The adenine-copper compound is suspended in hot water, decomposed with sulphuretted hydrogen, and the filtrate from the copper sulphide evaporated to dryness on the water-bath. The residue, consisting of nearly pure adenine, is dissolved in 5 per cent. of sulphuric acid, and the adenine sulphate, which is readily soluble in hot, but very slightly soluble in cold water, allowed to crystallise. The usual tests can then be applied.

The acid should be white or at the most have a very faint buff color. It should be completely soluble in an aqueous solution of sodium acetate or in dilute solutions of ammonia or of sodium or potassium hydroxides. The solutions in these reagents should be bright and almost colorless. When a few drops of hydrochloric acid are added to a solution of the sodium salt in water the acid should be precipitated as a white curdy substance, and on the further addition of a large excess of the hydrochloric acid this should dissolve completely. An aqueous solution of the sodium salt should give with cupric acetate, calcium chloride, and silver nitrate the reactions described above.

TESTS FOR THE ABSENCE OF PROTEIN

Direct Reaction.—A solution of the acid in an excess of caustic soda should give, on the addition of one or two drops of dilute copper sulphate solution, a greenish blue color with at the most a faint tinge of purple. The test is quite sufficient, but occasionally the following test is applied:

A 5 per cent. solution of nucleic acid in a small excess of ammonia, when heated in a bath at 105° C., should give at the most a slight turbidity.

In connection with these tests it may be pointed out that the removal of the last traces of protein matter from nucleic acid involves a very troublesome series of treatments, and that acid of high commercial quality will usually give an indication of the presence of traces of protein when subjected to the above tests. The second of the above tests is the more severe, inasmuch as an amount of protein equal to not more than 0.1 or 0.2 per cent. (expressed on the acid) gives a very appreciable volume of precipitate.

Inorganic Phosphate.—To a solution of the acid in excess of ammonium or sodium acetate a few drops of acetic acid are added, and then a little uranium acetate. A flocculent precipitate is formed, which in the absence of more than a trace of inorganic phosphate should dissolve completely on boiling. A considerable excess of alkaline acetate is necessary in this test.

ESTIMATION OF NITROGEN AND ORGANIC PHOSPHORUS.

Nitrogen.—This is estimated by the Kjeldahl method in the ordinary way.

Phosphorus.—A weighed quantity of the acid is fused with six times its weight of sodium carbonate containing 10 per cent. of potassium nitrate. The fused mass is taken up with water, and in this solution the phosphoric acid is estimated either by the molybdate method or by direct precipitation with magnesia mixture in the presence of a little ammonium citrate.

It will be seen that the formula given above corresponds with 16.1 per cent. of nitrogen and 9.5 per cent. of phosphorus.

Commercial nucleic acid of good quality ought to contain not much less than 15 per cent. of nitrogen and 9 per cent. of organic phosphorus (expressed on the moisture-free sample). The examination of nucleic acid should always include these two items, and the ratio of the percentage of organic phosphorus to that of nitrogen is one of the best *criteria* of the purity of the acid, since, if this ratio (1:1.7) is approximately correct, the presence of any appreciable proportion of the products of hydrolysis is excluded.

DISCUSSION.

The chairman (Mr. W. T. Burgess), in inviting discussion, remarked on the high percentage of nitrogen which nucleic acid contained, and asked whether it could be estimated satisfactorily by the Kjeldahl process, or whether some "ultimate" process would have to be used.

Dr. Winter Blyth, referring to the identification of the nucleic acid by the production of adenine and guanine, asked whether there was any other method which would require smaller quantities than 9 or 10 grms., and also whether Mr. Chapman could say how the nucleic acid was secreted, and in what manner it affected the urine. Presumably the phosphates would be increased, and possibly the amino-acids.

Capt. R. H. A. Plimmer asked whether Mr. Chapman had any further information on the subject of the increase of leucocytosis by nucleic acid used in surgical injections. It had been shown that meat extract caused an increase of uric acid in the urine, and meat extract contained purine and pyyrimidine bases, which were constituents of nucleic acid. This suggested that the uric acid might be produced from the pyrimidine bases, but it might be the result of some synthetic process in the body. He had been hoping that Mr. Chapman would have described some method for the quantitative chemical analysis of the decomposition products—for the estimation, for instance, of the quantity of guanine yielded. Such quantitative analysis was a difficult matter, and Mr. Chapman's paper gave an increased power to deal with it. Some years ago Professor Scott and he (the speaker) had discovered a method of detecting the minutest quantities of inorganic phosphorus or phosphate mixed with organic phosphorus compounds, using an ammonium molybdate reagent made with hydrochloric acid and containing some potasium persulphate. A mixture containing organic but no inorganic phosphorus compounds gave merely a yellow coloration, but if inorganic phosphate was present a yellow precipitate was produced.

Mr. H. F. E. Hulton asked whether Mr. Chapman would include absence of the biuret among his criteria of the purity of nucleic acid.

Mr. Chapman, in reply, said that the total nitrogen in the nucleic acid was readily obtained by the Kjeldahl process. As to the question of obtaining enough guanine and adenine for purposes of identification, there was no difficulty nowadays in obtaining sufficient nucleic acid to enable one to work with the 10 grms. required for this purpose.

Mr. Chapman, continuing, said that he did not know precisely what happened in connection with the increased leucocytosis which resulted from the use of nucleic acid, nor did he know the reason for the increase. That it did occur there could be no reasonable doubt, for the German literature on the subject was specially voluminous, and numerous experiments on this property of nucleic acid had also been made in France. Nucleic acid was, in fact, being used in considerable quantities for this particular purpose, and appeared to afford material help. He had not attempted the estimation of guanine. He was much obliged to Captain Plimmer for the reference to his special molybdate reagent, and should certainly try it. He was obliged also to Mr. Hulton for his reminder about the biuret reaction, which was, however, dealt with in the paper. This reaction should be practically absent. On dissolving the acid in a slight excess of caustic potash or soda and a few drops of copper sulphate there should be not more than the faintest possible tinge of purple; more than that would, of course, indicate the presence of protein.

Electric Propulsion for the U.S.S. New Mexico—I*

The Highly Efficient Generators of Our New Dreadnought

By C. S. Raymond

THE use of steam turbine-generators of considerable size began with the installation of the 5,000-kw. 500-r.p.m. machine for the Commonwealth Edison Company of Chicago, Ill., in the year 1903.

During the period of 1903 to 1913, inclusive, vertical turbine-generators of capacities from 5,000 to 20,000 kw. were made in vast quantities. The rotative speed was increased from 500 r.p.m. to 750 r.p.m for 25-cycle machines having 4-pole generators; and to 720 r.p.m. for 60-cycle machnes having 10-pole generators.

Great progress was made in turbine efficiency. Generator design was radically changed, due to the increased rotative speeds. The salient pole type was rendered obsolete, it being necessary to design a smooth core type of rotor having a distributed winding.

Many improvements were made in ventilation.

Important improvements were made in the design and support of stator coils to prevent distortion under short-circuit strains. Stator punching material was developed which reduced the core losses by 20 to 30 per cent. Temperature coils were introduced by which hot-spot temperatures could be determined. These changes were accompanied by the adoption of improved insulating materials, methods of manufacture, and application.

Rapid advancement in the quality of materials obtainable, constant research work, and the ever-present demand for better efficiency led advance in the rotative speed of steam turbines. The speed of 25-cycle units was increased from 750 r.p.m. to 1,500 r.p.m. involving a change from 4-pole to 2-pole generators; 60-cycle machines from 720 r.p.m. to 1,800 r.p.m., changing the 10-pole generators to 44-pole generators; while some of the smaller 60-cycle machines, up to and including the 5,000-kw. size, were developed with a rotative speed of 33,600 r.p.m. involving a 2-pole generator.

Referring to Fig. 1, a relative weight curve, assuming as unity the weight per kv-a. for a 7,500-kv-a. flywheel generator running at 75 r.p.m., a marked decrease in weight is shown to have taken place in the period from 1903 to 1918, inclusive. The curve is based on 25-cycle turbine-generators with the exception of the point for the year 1918 which represents the relative weight per kv-a. for the 34-cycle, U.S.S. *New Mexico* generators. A relative weight curve for 60-cycle turbine-generators, due to the higher rotative speed and lighter stator cores, would show to even a greater degree the decrease in weight per kv-a.

Judging from the electrical and heating characteristics of the 45,000-kw. generator, the limit of capacity has not yet been reached.

The installation in 1903 of the 5,000-kw. turbine-generator marked a distinct epoch in steam-turbine units. Parallel with this is the application of the high-speed turbine-generator for propelling ships by electricity, made possible by improvements in the art by which fuel consumption and weights per kilowatt have been greatly reduced. Experience gained from a large number of machines in operation, including the electrically propelled U.S.S. Collier *Jupiter*, has resulted in the elimination of untried constructions and materials in the turbine-generators for the U.S.S. *New Mexico*. The purchaser and builder have every reason to expect successful operation by these units with respect to the three cardinal principles: reliability, economy and maintenance.

Highest type of rotor for high-speed turbine generators

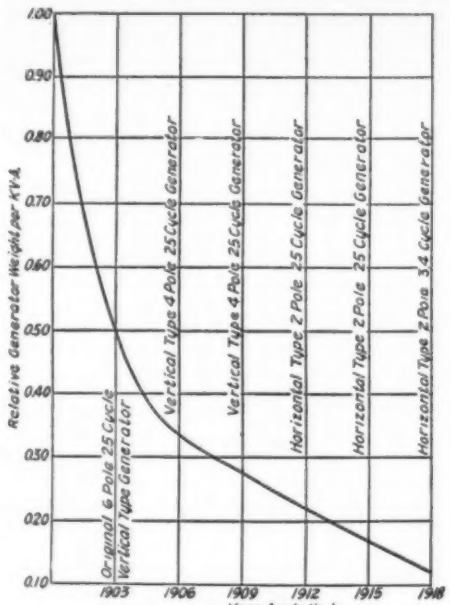


Fig. 1—Relative weight per Kv-a capacity

ELECTRICAL DESCRIPTION.

The U.S.S. *New Mexico* is equipped with two main turbine-generator units, each generator designed to develop 10,500 kw. at 78 per cent. power-factor, and 13,500 kv-a. at full speed of the ship, and to carry a 25 per cent. overload (16,850 kv-a. at 78 per cent. power-factor) for four hours. The rotors have two poles and a maximum rotative speed of 2,100 r.p.m. which corresponds to a frequency of 35 cycles. The stators are wound two-phase with leads brought out from the beginnings and endings of each phase to an 8-pole, double-throw, disconnecting switch placed in the main circuit between the generators and the motors. By manipulating this switch two generator connections are available: first, diametrical, two-circuit, low-voltage (3,000 volts); and, second, square, one-circuit, high-voltage (4,240 volts). With a constant flux, the voltage will vary directly or inversely as the $\sqrt{2}$ depending on the connection involved. Suitable interlocks have been installed, making it impossible to operate the two generators in parallel.

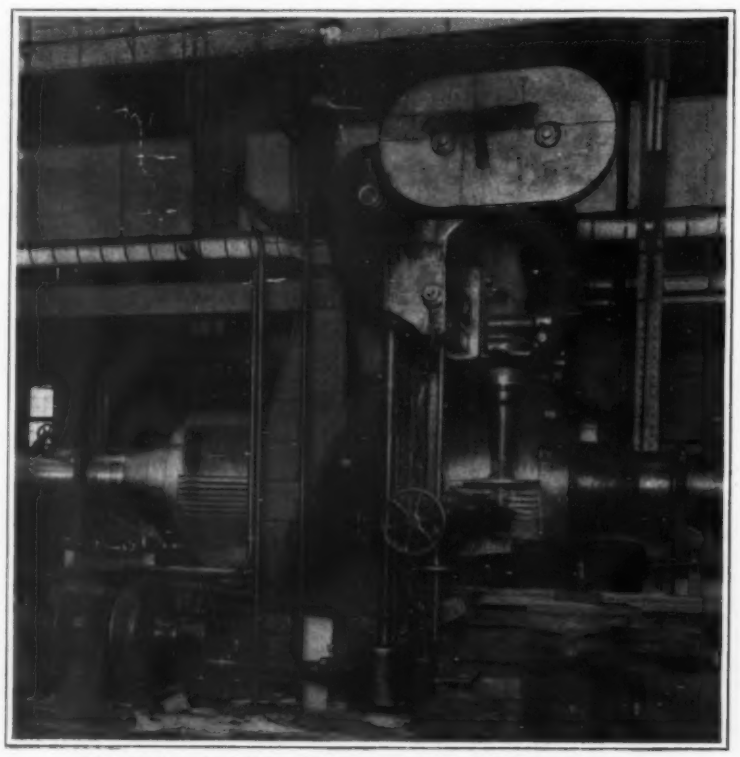
All speeds of the ship up to 17 knots inclusive are obtained by the use of one generator having the low-voltage-connection, the generator furnishing power for driving the four motors. Above 17 knots, two generators having the high-voltage connection are used, each generator furnishing power driving two motors. The generator efficiency curve, taken at loads and speeds corresponding to 10, 15, 19, and 21 knots, shows a uniformly good efficiency throughout a wide range of load. It is based on actual running conditions, and includes the windage loss of the rotor. The main turbine-generators are used only for propelling the ship, and are in no way connected to the lighting or other auxiliary power circuits.

The induction motors, direct-connected to the ship's propeller shafts, are two-speed motors with connections for 24 to 36 poles. The speed reduction between the generators and the motors when using the 24-pole motor connection is 12 to 1, and with the 36-pole connection, 18 to 1. Hence, the extreme range of generator r.p.m. for the specified operating speeds of the ship, 10 to 21 knots, is approximately 1,440 r.p.m. to 2,100 r.p.m. In order to calculate the generator efficiency with accuracy, the windage loss must be carefully determined at various speeds, for this is the largest single loss. Tests were made at the factory to determine the windage of the rotor and the results show the windage loss varies approximately as the cube of the speed.

GENERATOR CHARACTERISTICS.

The *New Mexico* generators are conservatively designed. Compared with the maximum rated machines for land practice, the relative armature reaction is considerably lower and the densities in the magnetic section are slightly higher. The characteristics of these generators are best shown by the curves in Fig. 2 which are based on data taken from a four-hour maximum-load endurance run. As indicated, sufficient excitation current is applied to the generator fields to insure keeping the motors and generators in step. In other words, the generators are not working at the peak of the kilowatt curve, but at a safe distance down where there is sufficient margin in power to take care of the rudder swings and heavy seas. Based on the maximum power-factor of the motors, 79 per cent., the generators have a margin in power of 24 per cent. with the excitation given.

An interesting test was made with approximately maximum load and speed of the ship using one generator to drive four motors. With the kilowatt output and speed of the generator held constant, the excitation current was gradually reduced to a value at which the motors and generators dropped out of step. The sea was smooth and the rudder held amidship. In Fig. 3, two curves of this condition are given, one from observed readings and the other from calculated values. The point at which the motors and generators dropped out of step is clearly shown. This unstable condition corresponds to operation at the peak of a kilowatt-line current curve. In other words, the generators with the excitation reduced to the breaking-out point, have no margin in power, and the excitation must be increased to insure stable operation on account of rudder swings and rough seas.

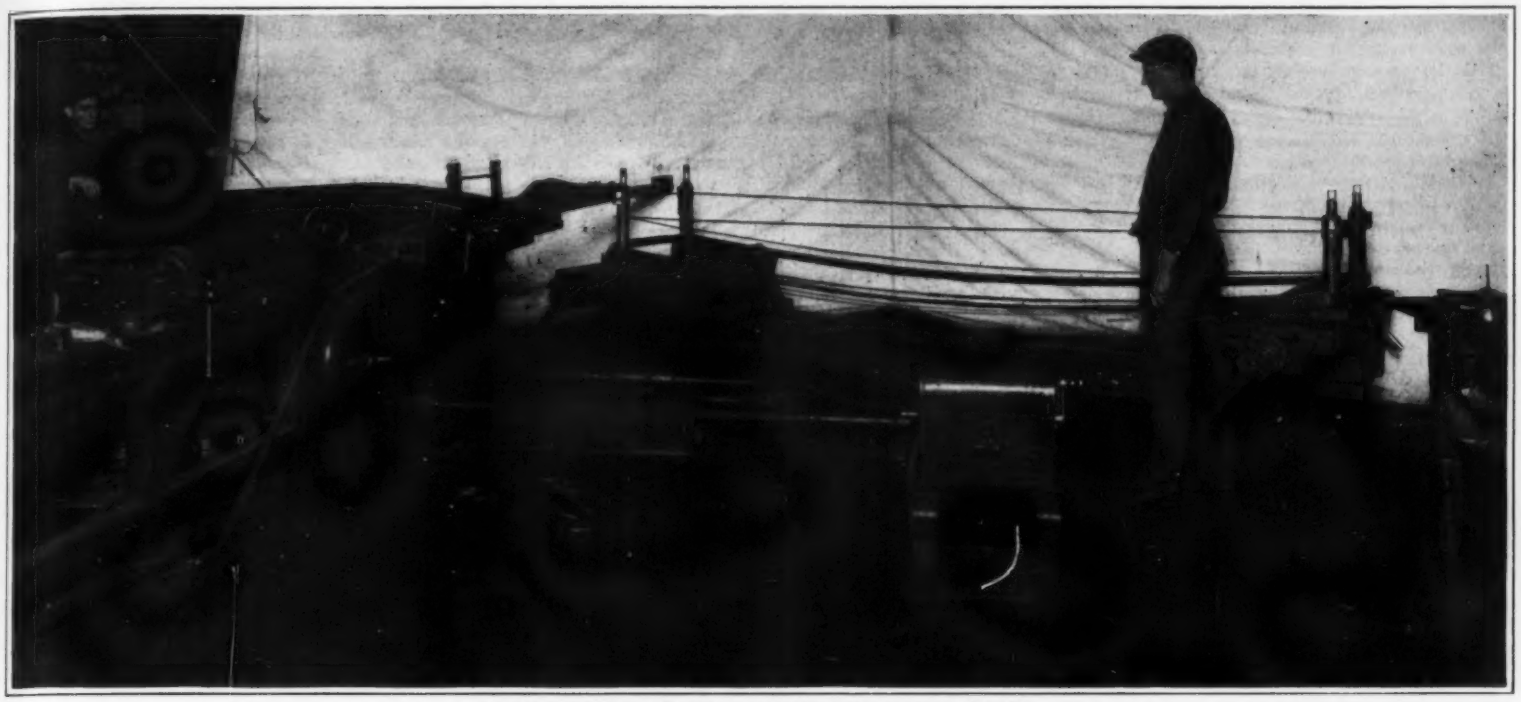


Machining the Field Winding Slots in the solid forged rotor

OVER EXCITATION.

Another very important feature in regard to the generator design, is the con-

*From *General Electric Review*, Schenectady, N. Y.



Special machine winding edgewise the strip-copper field coils

dition of over excitation required for starting and reversing the motors. The turbine-generators have a fixed mechanical rotation, but the motors may be run in a clockwise or counter-clockwise direction by changing the phase rotation by suitable switching. A very important feature inherent with electrical propulsion is that full power is always available for either direction of propeller rotation. From actual reversal tests, at maximum speed of the ship, the observed excess excitation current required for reversal was approximately 60 per cent. above that for the steady running condition. The line current increased to approximately three times the steady running value. That these high values of current are not injurious to the generator is due to the extremely short time required for reversal and the large heat storage capacity of the generator. The observed time for reversal from maximum speed ahead

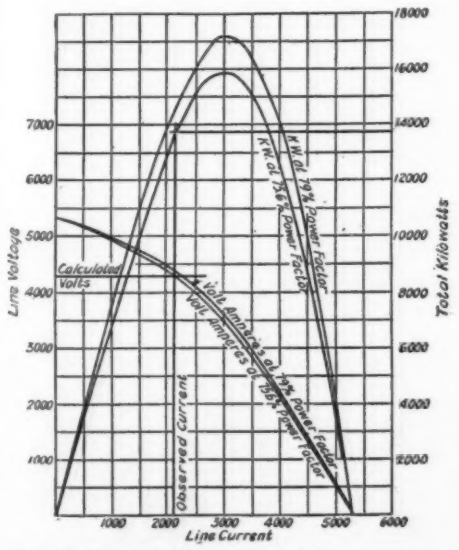


Fig. 2—Characteristic curves of the generators

to full reversing speed astern, with the motors in the 36-pole or low-speed connection, was approximately 20 seconds. To pull the motors into step in the reversed direction of rotation required holding the over excitation on the generator fields approximately eight seconds, the balance of reversal time being consumed in the release of the interlocks and in the switching operation.

TEMPERATURES.

An evidence of the conservative design of the generators is the recorded temperature rise during the maximum-load endurance run, the power developed being 31,000 h.p. and the speed of the ship 21.3 knots. The maximum temperature rise on the armature windings as measured by temperature coils was 39° C. The temperature coils were located between the upper and lower layers of the windings in the slot at the center of the core and recorded the approximate hot-spot temperatures. The rotor or field temperatures as indicated by rise in resistance of the field winding indicate a safe working margin on the guaranteed actual temperature of 150° C., allowing for the temperature of the air entering the generator to be as high as 45° C.

MECHANICAL DESIGN.

The mechanical design of the generator is similar to that of other machines developed for central power stations. In fact, this type of machine has been manufactured in such numbers of varying frequencies and capacities that it is possible with slight changes to use standard designs. Fig. 4, page 358, shows a longitudial cross-section of one of the two generators for the *New Mexico*.

One feature that differs from land practice is the omission of the turbine and generator base castings. The turbine casing, generator stator frame, and bearing standards are bolted directly to a stiff structural steel foundation which is securely tied in with the ship's structure.

STATOR.

The stator or armature is of a compact design. The stator frame is of the sectionalized I-beam type which consists of several circular I-section castings, properly spaced and held together at their outer periphery by boiler plates, these plates being hot riveted to the I-section castings. The I-section castings after being properly spaced and supported are carefully bored out at their inner periphery for the attachment of rectangular steel bars, these bars forming the dovetail ribs for assembling the stator core punchings. The advantage of this frame over the solid cast type is the great saving in weight, being approximately one-half as heavy. Other advantages are: the elimination of dangerous shrinkage strains always present in the solid cast frames, the simplified patterns and castings, and the general adaptability for shortening or lengthening and respacing of dovetail ribs to suit the various punching segments. The armature core or magnetic section is composed of thin laminations, each one being insulated with enamel. Special silicon steel is used to insure low losses. The punching segments and the dovetailing to the stator frame ribs are so designed that even with the great radial depth necessary for 2-pole turbine-generators, the laminations lie flat. With the final pressure applied and the clamping flange assembled, a uniformly tight core is obtained, one that will stay so indefinitely.

Straight steel strips having an I-section were spot-welded to the punching segments and form the air ducts in the stator core. These strips or space blocks are so arranged that the air flows radially through the core. A liberal number of ducts are used to insure a plentiful supply of air and to expose the maximum amount of surface to the air.

The stator coils are of the conventional barrel type, two coils in each slot. The conductors consist of insulated rectangular wire which was formed into the proper shape in a bending form. Before the application of external insulation, the conductors were moulded in a steam mould. Following this treatment they were placed in a tank and subjected to vacuum to remove the moisture, and then as shown (view omitted) a compound was forced into the coil under pressure to entirely fill the spaces between the rectangular wires. External insulation was afterward applied, consisting of mica tape which extends uniformly over the whole coil. The moulding and filling operations were again repeated. Recognizing the severe conditions that would be imposed on the insulation by the salt-laden ventilating air, water proofing insulation treatments were applied to the coils, special attention being directed to the connections and to the portions of the coils beyond the stator core. By heat treatment, the insulation of the coils is prevented from loosening under the most severe operating conditions. The coils after being heated by current were assembled in the stator core in the manner shown on our first page.

To prevent distortion of the ends of the coils under short-circuit strains, they were securely laced to insulated binding bands. Blocks properly spaced were

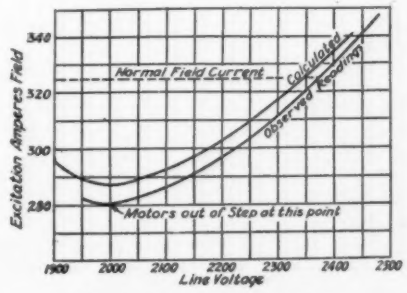


Fig. 3—Two excitation curves

placed between the adjacent coils. The effectiveness of this structure has been demonstrated many times by actual short-circuit tests and accidental short-circuits in such machines under commercial load. Careful inspection failed to reveal any movement of the coils.

ROTOR OR FIELD.

The electrical and mechanical limits of turbine-generators are encountered in the design of the rotor or field. The electrical limits are confined to the heating of the field windings and the mechanical limits to the centrifugal strains and to the critical speed. The rotating elements of the turbine and the generator are supported by four bearings and are coupled together by a flexible jaw type coupling. This coupling is placed between the adjacent turbine and generator bearings and with them is contained within a common housing.

Radial slots for the rotor windings were machined in the solid forging in the manner shown in our third view. The rotor coils are made of rectangular copper strip wound on edge by a machine, which forms the corners of the coils and varies the span of each turn the

correct amount. Before assembling the coils they were annealed and the turns insulated with mica tape. The coils were assembled in the slots one turn at a time.

The slot insulation consists of mica and asbestos sheets placed between horn fibre for mechanical protection in assembling the turns. This insulation is a continuous sheet and extends the entire length of the slots. After assembling, the coils were heated by electric current, cemented, and pressed into their proper position under a pressure exceeding that to which they are subjected in operation.

The portion of the coils outside the rotor body is insulated with mica tape. Over the mica tape is a layer of asbestos tape which serves as a mechanical support and protection to the mica. In the slots the insulation was lapped over the coils, cemented, the necessary filling strip inserted, and steel wedges driven in to retain the coils in the slots. The end coils are carefully supported by moisture-proof blocks to prevent any movement. To protect the ends of the coils from moisture, several layers of insulating varnish were applied and each layer baked until dry.

To support the ends of the coils against centrifugal force, forged-nickel-steel binding-rings were shrunk on over them. One end of the ring is supported on lugs integral with the rotor body, the other end on a centering spider whose inner circumference rests on the shaft. Thus the shrinkage stress is taken by steel members and not by the insulation.

COLLECTOR RINGS.

The collector rings are placed outside the collector-end bearing and are encased in a neat ventilated removable cover. The collector rings are special heat-treated steel forgings and were shrunk on over hard mica bushings to the cylindrical collector shell, this shell being pressed on and keyed to the end of the main shaft forging. Soft graphite brushes are used and spaced so that the entire width of collector ring has brush contact. A helical spring is placed directly over the center of the brush and by adjusting this spring any desired brush pressure may be obtained. The parts pertaining to the support and control of the brush pressure are light and extremely quick in action, and when the brush pressure is properly adjusted all sparking between the collector rings and the brushes is eliminated.

VENTILATION.

With the high-speed turbine-generators, a system of forced ventilation is absolutely essential since the natural windage of the solid forged cylindrical rotor is negligible. The volume of air required depends on the losses in the machine. The proper volume of air per kilowatt lost has been carefully determined from experimental data and from experience gained from a large number of machines of various capacities in service.

The *New Mexico* turbine-generators are ventilated by two duplicate and separate ventilating systems, one for the starboard generator and the other for the port. The air is taken from out-of-doors through ducts placed just back of the upper superstructure on the starboard and port sides. The openings in these ducts face aft and are approximately 10 feet above the main deck floor and are designed to prevent the entrance of rain. Auxiliary blowers of ample capacity draw in the air through these openings and force it down to the bottom of the ship into chambers directly under the generators. These chambers and the air connections to them are made water tight and the danger of bilge drainage entering with the air into the generator windings is practically eliminated. Fans mounted on each end of the generator rotor take the air from these chambers and force it axially through the airgap. The air then passes radially through the several air ducts in the stator core, thence circulates around the outer periphery of the stator punchings in the spaces formed by the I-sections of the stator frame. An exit duct of liberal area is connected to the top of the stator frame and the heated air is taken away through this duct, which passes through the several decks and exhausts out-of-doors. The pressure-volume curve, Fig. 5, represents actual factory test values of the performance of the fans mounted at each end of the rotor, the air being taken directly under the stator frame and exhausted through a long circular pipe attached to the top of the stator frame. The volume of air varies directly with the speed, the pressure as the square of the speed. The volume of air under actual operating conditions is approximately 10 per cent. higher than was obtained in the test, due to the throttling at the entrance of the measuring pipe.

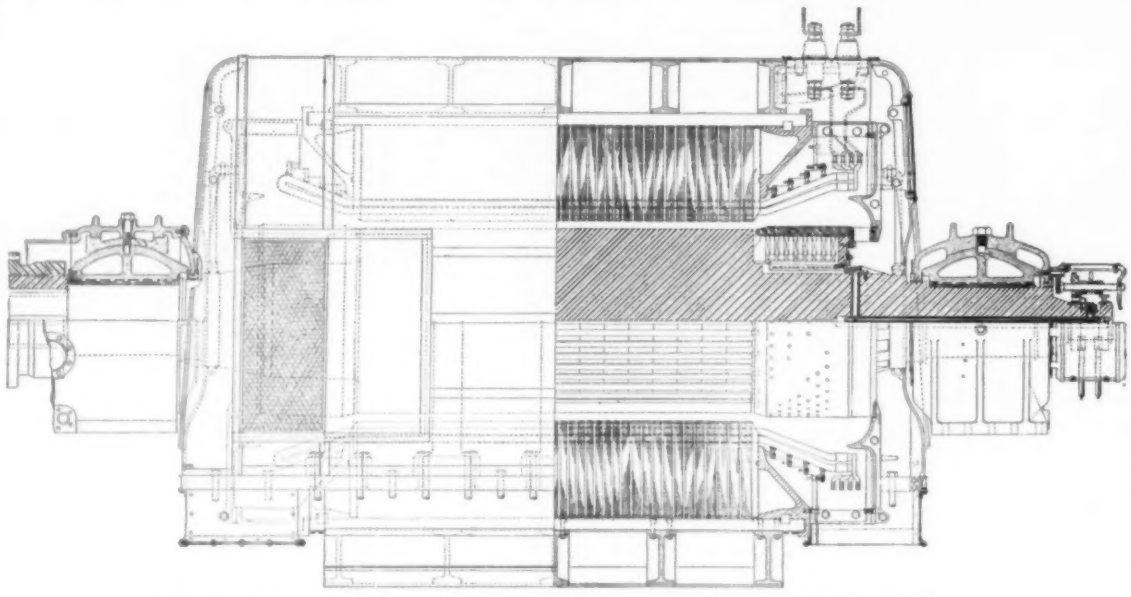


Fig. 4—Cross-section of one of the two turbine-generators for the U.S.S. New Mexico

CONCLUSION.

Recognizing the importance of this installation from both the builder's and purchaser's view point, Secretary Daniels arranged for the presence of the interested designing engineers to witness the trial tests. All were deeply impressed with the intelligent and efficient manner in which the various tests were planned and conducted. Naval experts and visiting engineers were enthusiastic over the ease with which the maximum

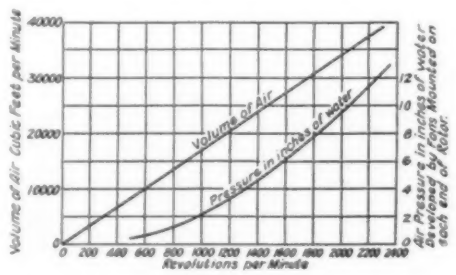


Fig. 5.

load and reversing tests were carried out, both in regard to the operation of the propelling equipment and its control by the operators.

(To be continued.)

Synthetic Rubber

A VERY instructive communication on the difficulties with which Germany has to contend owing to the dearth of the most important raw materials for the war industries was made by Dr. Duisberg, one of the leading chemists of the Elbertfeld Farbenfabriken, in the meeting of the Bunsen Gessellschaft, held at Berlin in April last. It will be remembered that in the years 1910 to 1912 Fritz Hoffmann, of that firm, had succeeded in preparing isoprene and dimethylbutadiene, hydrocarbons somewhat resembling benzene, which on long-continued boiling (for weeks or months, it is now admitted) turned into a substance which showed the chemical reactions and some of the properties of caoutchouc. This synthetic product was used as a rubber substitute or as addition to rubber, and the process seemed commercially possible in those days when rubber was in Germany 30 marks per kilogramme. When the price went down to 4 marks, the Leverkusen works of the firm gave up the new process. There was another process, tried and afterwards abandoned, in these works; reduction of acetone by means of aluminium to pinakone, which is closely related to methyl-butadiene. The war once more forced attention on these processes. Meanwhile, however, aluminium and acetone had become equally rare and precious. As regards aluminium the manufacture of the metal was taken up in Germany, which has now three works. With respect to acetone, potatoes had been a raw material, but they could not be spared any longer. Böttinger found that with the aid of the bacillus *macerans* he could make acetone from putrid potatoes, the fermentation yielding a mixture of about two parts of alcohol and one part of acetone but the bacillus proved very sensitive, and the process was not a success on a large scale. Calcium carbide was then utilised to a larger extent than before the war; it yields, with water, acetylene which in the presence of a contact substance (mercury salts) is converted into acetaldehyde; the aldehyde can be oxidised to acetic acid; blown over another contact substance the acid loses the elements of CO_2, turning into acetone. This process is worked at Leverkusen, at Höchst and at Burghausen on the Alz. The rubber manufacture was then resumed. The rubber industry was not favorably disposed to the methyl caoutchouc, however, which was not real rubber, absorbed oxygen from the air, and gave trouble in the vulcanisers. This trouble was overcome by the aid of piperidin and other ingredients. The new hard rubber (ebonite) so improved was equal to the old product and dielectrically even stronger; the accumulator boxes of the U-boats are made of this ebonite. The soft rubber, however, was not perfect yet; at ordinary temperature it resembled leather more than rubber, and became elastic only when warm. The addition of dimethlyaniline and of toluidine—both valuable products, it need not be pointed oue—cured these defects. In the improved condition the rubber is used for making the tyres for heavy motor vehicles and also for artificial teeth. The Leverkusen works can now supply 2,000 tons of rubber per year, which is about one-eighth of the amount of rubber wanted. Meanwhile Merling has prepared isoprene from acetylene and acetone, and that process, though still in the experimental stage, is also regarded as promising. As to the outlook for these synthetic rubbers in normal times Dr. Duisberg was guarded.—*Engineering.*

Improved Sparking Coil

ACCORDING to French Patent, No. 484,177, of E. Balzarini, a new method is disclosed for improving the action of sparking coils. In the method of construction usually adopted the secondary current often persists after the primary winding has been re-established by the interrupter, and the inverse current at the make suddenly damps out the secondary current that is still flowing, and then reverses its direction. This has several drawbacks, and in particular diminishes the efficency of the apparatus.

The modification now proposed consists in providing two similar primary windings, put alternately into circuit by the interrupter, the connections being such that the successive primary currents magnetise the core of the sparking coil in opposite directions. Thus the electromotive force in the secondary circuit at the make agrees in direction with the existing flow of current. The result is that the current in the secondary circuit is rectified by a high tension commutator.

A similar idea may be applied to the running of a coil off a source of alternatng current. In this case only a single primary winding is needed, and the interrupter is run by a synchronous motor at such a speed that the successive pulses of current are in opposite directions in the primary winding.—*Revue générale de l'Electricité.*

Recent Developments in Marine Lighting—I*

The Present Status of the Attended Light and Lightship

It is only within comparatively recent years that any important improvements have been effected in lighthouse design and construction, and that the art has emerged as a separate and somewhat specialised branch of engineering.

The Pharos of Alexandria, which was erected in the third century B. C., is one of the most famous of the early lighthouses, but it was by no means the first fixed marine light. There was certainly a light at Cape Sigeum, now known as Cape Yeni-Shehr, which is on the Asiatic side of the Dardanelles entrance, not far from Kum Kale, a name that became very familiar during the Gallipoli campaign, and it is believed to have been in existence since the twelfth century B. C. It is probable that Æneas, after the fall of Troy, embarked from the shore close to the Sigeum lighthouse, and it is certain that other lighthouses had been erected on the Mediterranean coast before the Christian era. These structures succeeded the earlier method of employing fire beacons, and it was by beacons that the lighting of the coasts of Great Britain was first accomplished, many of them having been put up by the Danes and Norsemen. The first real lighthouses in the British Isles stand to the credit of the Romans. There are the remains of a Roman lighthouse at Dover. Relics of another ancient lighthouse, ascribed to Caligula, have been found on the cliffs of Boulogne. All the early lighthouse buildings have been swept away, but the Phœnician Pharos at Corunna is known to have been re-established as a lighthouse about 1634, and it is now furnished with a dioptric apparatus which was installed in the year 1847. The Corduan light at the mouth of the Garonne has been in existence from the days of the old open brazier down to the modern period of dioptric apparatus. For centuries, however, little or no progress was made, and it is correct to say that modern lighthouse engineering is the development of the last century. The Bell Rock Lighthouse, built in 1810 by Robert Stevenson, is the oldest rock lighthouse in existence. Up to the year 1800 there were fewer than forty lighthouse stations and floating lights in Great Britain, and many of them were private property, whereas at the present day there are considerably over a thousand British coast and harbor lights.

Trinity House, which is now charged with the provision of lighthouses, buoys and beacons for the English coast, did not receive the necessary authority until the Elizabethan era, although it was in existence at an earlier date as an association of mariners, with headquarters at Deptford. The management by Elder Brethren, which system has survived down to the present day, was first begun in the year 1604, and the headquarters of the authority have been established in Trinity-square since the year 1795. No general lighting of the Scottish coasts was undertaken until 1786, and the Commissioners of Northern Lighthouses, who now control the lighting of the coasts of Scotland and the Isle of Man, were incorporated in 1798. The lighting of the Irish coasts is controlled by the Irish Lights Commissioners. The development of these three organisations represents in a very considerable measure the progress of marine lighting, as engineers of these various bodies have either suggested the lines of advance or have co-operated with manufacturers in most of the improvements which have been effected.

The type of light is, of course, decided by sea conditions. The object may be (*a*) to erect a landfall or making light, of which the Lizard, Skerrymore, Fastnet, Ushant, Cape Race, are examples; or (*b*) a warning light, of which the Eddystone is an example, although many lights serve the dual purpose of landfall and making lights; or (*c*) a harbor or leading light. The selection of the type of lighthouse also depends upon the character of the site and materials available for construction. The optical apparatus now generally employed is defined as "dioptric," but to be quite accurate it should be termed "catadioptric," as it employs both reflection and refraction. The old catoptric system, in which the light was reflected only is now practically obsolete, as its retention in lightships where, until a comparative recent date, metallic reflectors were employed, is no longer deemed necessary. The first revolving light is believed to have been erected at Marstrad, in Sweden, in 1783, but it was not until the year 1822 that Fresnel introduced the dioptric system, although reflectors composed of pieces of silvered glass set on a parabolic plaster mould were employed in the Mersey Lights in 1763, and spherical metallic reflectors were used in France in 1781, and parabolic mirrors in 1790. Alan Stevenson, to whom is assigned the credit of having introduced the dioptric light into Great Britain invented a cylindrical belt, divided into sections and having helical joints, and replaced the Fresnel mirrors by horizontal totally reflecting prismatic rings to secure the equal distribution of the light, a practice which survives down to the present day, except that for certain services a larger number of smaller prisms is employed.

The ordinary parabolic reflector allows about one-third of the rays to escape by natural divergence, and to prevent this waste the holophotal reflector was introduced by Thomas Stevenson in 1849. It was not until the year 1874 that group flashing on the Hopkinson system was adopted, this effect being secured by splitting up the lens into several portions so as to give a group of two or more flashes followed by a long eclipse. A somewhat notable improvement in revolving apparatus was made to a design of Messrs. Stevenson by Messrs. Barbier and Fenester in 1885. Reference is here made to the hyper-radiant apparatus which is claimed to be, from an optical standpoint, the most efficient in existence. Those familiar with this system will recall the fact that the use of enlarged prisms above and below the lenses ensure all the rays of light being utilised, while a further advantage is that only one central flame is required.

When a light of great power is necessary two sets of apparatus superimposed are sometimes used, the Bishop's Rock and the Fastnet being notable examples of that method, which carries with it the advantage that a light of high power can be obtained with a lantern of comparatively small diameter. The French lighthouse authorities have installed twin lights, placed alongside each other, instead of being superimposed.

In the case of revolving apparatus the necessary motion is produced by means of a clock driven by a falling weight, but for small apparatus the motion has been derived from the current of hot air rising from the burner acting on a fan, a method which has since been adopted in the Lindberg unattended system. With heavy and high speed apparatus it is usual to carry the rotating parts in a trough of mercury. For small occulting apparatus or for port lights spring clocks are used for revolving the screens.

ILLUMINANTS.

Different forms of illuminants are employed in lighthouses. The old coal fires which were used in the earliest days survived in England until 1822, and there were examples of such lights in service in the Baltic until 1850. Candles as well as oil lamps have, however, been employed for a long period, and Smeaton's Eddystone was fitted with twenty-four tallow candles. The early oil lamps used whale oil, for which Argand devised the cylindrical wick burner. Concentric wicks and four-wick lamps were introduced at a later date, and experiments were made with large numbers of wicks, while almost every kind of oil was tested under service conditions. Paraffin oil eventually superseded its rivals, and was generally adopted where oil lamps were installed. Coal gas is not favorably regarded by lighthouse engineers, but oil gas, particularly when used in conjunction with the incandescent mantle, has given good results. The principal illuminants now employed are oil vapor, acetylene, and electricity, but the latter only to a small extent, and practically no new electric installations for large lights have been ordered since the incandescent oil burner was developed to a high degree of efficiency. It is, however, generally recognised that for small lights incandescent electric lamps present certain advantages. With oil lighting the oil is supplied in the vaporised condition to a burner fitted with an incandescent mantle. In starting up the vaporiser is heated by a subsidiary spirit flame. Various types of burners are in service, including the well-known Chance burner, and that designed by Sir Thomas Matthews, engineer to Trinity House, as well as the burner with which the name of Diamond is associated. These burners are suited for oil having a flash point of from 145 to about 160 degrees Fah.

The acetylene light is claimed by its advocates to have a greater penetrating power through fog than any other light, but this statement is held to be one which requires confirmation. When acetylene is employed in lighthouse work the gas is either supplied in cylinders, or, as is more common, is generated on the spot. The disadvantages of acetylene for lighthouse work are that, in the case of large lights, the consumption of gas is considerable, and that both the first cost and upkeep are higher than where oil is used, and although acetylene burners can be constructed for use with mantles, which considerably decreases the cost per candle-power, even under such conditions acetylene compares unfavorably with oil from the point of view of cost. One advantage of acetylene installations in attended stations is that it does not require the keeper to be always in attendance, as in the case of oil installations.

THE MANORA LIGHT.

A typical example of the largest type of optical apparatus is that installed at Manora Point, in the Gulf of Kutch. In this case the revolving optic consists of four panels, each of 90 degrees horizontal angle, with a verticle angle of 121½ degrees. The lens or refracting segments in each panel consist of a bull's-eye and nine rings, the angle being 57 degrees. Twenty-two catadioptric or reflecting prisms are placed above the lens elements, and thirteen below. The glass elements are mounted in gun-metal frames, the weight of which is 2 tons 2 cwt., the optical glass itself weighing about 3 tons. The optic is mounted on a cast iron table, carried on an annular cast iron float immersed in a mercury bath in which it rotates. The total weight floated is about 7 tons, and 772 lb. of mercury are required in the bath. The bath and float are cast in sections machined and bolted together. The six cast iron columns forming the pedestal of the apparatus are fitted with detachable brackets upon which the mercury bath rests. The same columns support a cast iron table within the base of the optic, which serves as a platform for the burner, and carries a series of horizontal and vertical rollers, the former for the purpose of steadying the revolving portion of the apparatus, and the latter for supporting it in the event of the mercury bath being out of use for any cause. Under normal conditions there is a clearance of about 1/32 in. between the rollers and the corresponding track above them.

The apparatus is rotated by a clockwork machine placed alongside the pedestal. The driving weight is 3½ cwt. and the fall 22 ft. per hour. The weight descends through a tube constructed in the centre of the tower. The optic makes one complete revolution in thirty seconds; and produces a flash of .3 second duration every 7½ seconds. The focal plane is 149 ft. above high water, and the light is visible 18 miles.

The illuminating apparatus consists of an incandescent peteroleum vapor burner, with a mantle 85 mm. diameter. It is of the type of burners which have now superseded the old oil-wick burners, and which give greatly increased candle-power and considerable economy in oil. The fundamental principle is that the vapor oil is mixed with a fixed proportion of air and produces a flame of great intensity. The usual sizes of incandescent oil burners now supplied with lighthouse apparatus are 35 mm., 55 mm., 85 mm.; the intensity ranging from 800 to 4,000 candles, with a consumption of ½ pint to 3¼ pints of petroleum.

LIGHTSHIPS.

The earliest form of lightship was the Roman coast-guard galley, which carried at its masthead an open framework basket, in which a fire could be lighted to serve as a signal. In modern practice lightships are employed in situations where it is not possible to erect a lighthouse. The usual type of vessel is a steel ship, about 100 ft. in length between perpendiculars, and of about 23½ ft. beam, and very strongly built. The lightship, as we know it today, is mainly due to the initiative of two men—Robert Hamblin and David Avery. The former succeeded in obtaining a patent in the year 1730 for the lighting of the British coasts, although a century earlier a petition had been presented asking that a light should be placed to mark the Goodwin Sands. The patent granted to Hamblin was revoked shortly after its issue, but Avery succeeded in establishing friendly relations with Trinity House, and with its co-operation put the Nore Light in position in the year 1732. This was quite a small vessel fitted with a number of little lanterns fixed at the extremities of the yard arm burning oil in flat wicks, and it is not surprising to learn from old records that the light was dim and not infrequently blew out. Even in those early days, however, attempts were made to obtain characteristic lighting, and when a ship was afterwards placed at the Dudgeon it was given a different form to distinguish it from the Nore Light. At the beginning of the nineteenth century lanterns

(*Continued on page 368*)

*From *The Engineer*.

A Giant Insect*

The Cyphocrania Gigas of the Island of Amboyna

By Abbé G. Fouchier, Curator of the Catholic Institute Museum of Paris

CERTAIN creatures in Nature charm us by the beauty of their coloring or the elegance of their form and thus hold the interest and attention of the observer. The insect which forms the object of the following study is more apt to inspire a sentiment of fright, so strongly does it recall at certain moments the formidable creatures of another age in the various attitudes it assumes. The Cyphocrania Gigas, which is common in Amboyna and the neighboring islands in the Dutch East Indies, is one of the largest Orthopters known; with its legs extended it measures almost 33 centimeters. It has heretofore been found outside its native haunts only in the collections of naturalists and in museums, and its manners and habits have been entirely unknown because of practical difficulties in rearing it. Since Hagenbeck of Hamburg, the commercial monopolizer in the domain of natural history, was unable, in spite of his professional skill to furnish me with a living specimen of this orthopter for the Exposition of Living Insects held in Paris in 1914, I resolved to make a personal attempt at rearing the Cyphocrania in the hope of obtaining useful information. It is the result of these studies which are here laid before the reader.

It was sometime in May, 1914, that I received from Amboyna 430 eggs of the Cyphocrania. This egg is of oval form; in color a very brilliant brown, and it is hermetically closed by a rounded operculum or lid of the same color. I was not able to discover any point of suture or any sort of hinge between the egg and the operculum. I removed the latter with the point of a pin and beheld the insect rolled into a ball but appearing to be alive and ready to issue from the egg.

Such is the aspect of this egg if we confine ourselves to a rapid and superficial examination; but if we continue our studies by means of the microscope we are overcome with amazement at the wonders disclosed. The slightly convex operculum strangely resembles a sea-urchin deprived of its spines and is itself surmounted by a small convexity; it is ornamented with a series of rather irregular designs and variegated with different spots of singular coloring; none of the designs is repeated even once, and the black, brown, green and white of the coloring are agreeably mingled and render the general aspect analagous to the coloring of the adult insect.

When the operculum is inverted a small membrane appears somewhat resembling a flake of mica at first sight; but the microscope reveals a more delicate elaboration than any artist ever dreamed of making. This membrane is in the form of a perfect circle, resembles a tenuous spider-web shot through with thousands of the most brilliant metallic silver threads; from the center to the circumference extend a multitude of zigzag lines which do not touch each other. The outer edge of the circle is of a brilliant white; within this is a pale-colored portion and inside that is an area of somewhat deeper tint upon which a number of small dull spots are found. The internal membrane of a tarnished white resembles in form, color and texture the lining of a bird's egg.

I put all the eggs upon a layer of well sifted sand in a glass cage. This insectarium was kept in my kitchen where it was surrounded by the proper conditions of heat and humidity. The month was June, and the normal heat of that month was augmented during the day by that of a stove constantly in use. During the night the water in the center of the insectarium was heated by an alcohol lamp so as to maintain a constant state of humidity. On the morning of June 6 I observed a small insect, erect upon its legs, running towards the walls of this cage at high speed; its head was of a beautiful pale green; the legs of the same color were adorned at the joints with a bright red band, this red color extending to the extremities of the anterior legs. The very small antennae had at this time only nine rings, and like the eyes were of a very deep reddish brown in color; the last segment of the antennae was twice as long as the others. The abdomen was very much elongated, it alone measuring 13 mm., while the entire insect was only 24 mm. in length; the abdomen was of a dark green color with each of its nine divisions marked by beautiful bright red bands. At this stage neither the wings nor the wing-cases had made their appearance and the sex was not recognizable, but the lamellae of the abdomen were already quite visible.

The insect sought to perch, and ran about the space where it was confined a number of times without standing still. I offered it a guava leaf, but it refused this leaf which is so much sought for by some other orthoptera and I was obliged to find something else. After several unsuccessful attempts I had the pleasure of seeing it accept the leaves of the blackberry and of the purple beach. However, it did not seem to be very hungry; it ran from leaf to leaf and from branch to branch without standing still anywhere; had its prison been larger it would have fatigued the eye to follow its movements. I then offered it a rose, thinking it might prefer the flower to the leaf, but it did not notice it and continued its previous behavior. During its wanderings at a certain moment it approached the top of the cage upon whose glass plates were a few drops of water remaining from the evaporation of the night before; the insect rushed at these and drank with avidity.

A few days later another egg hatched, and I hastened to exhibit to the visitors to the exposition these two curious specimens of orthoptera; but the two little creatures, not being acclimatized, succumbed to the sudden variations of temperature to which they were exposed and lived only four days.

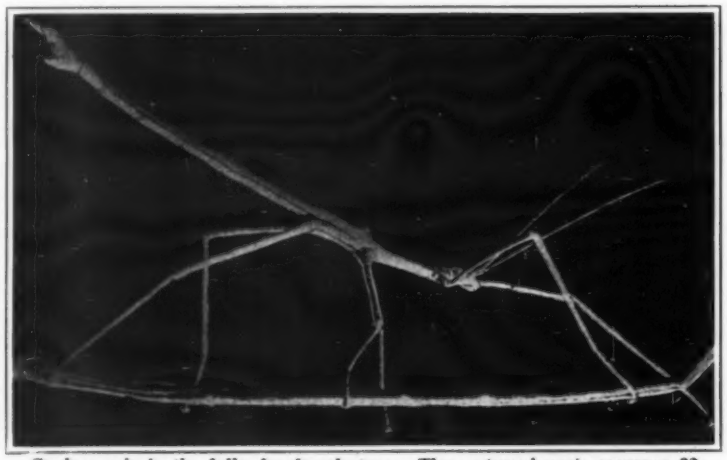
Feeling that my method of rearing was far from being a success I put all the eggs into a glass box and dismissed them from my mind. What was my surprise during the early part of the following October to find within the box a charming cyphocrania running around in the box with great agility. I at once placed the new hatched insect and the rest of the eggs within the insectarium; the result was unlooked for; by the 30th of July, 1915, I had obtained 384 insects out of the 430 in the incubator, and only 47 of these died in the state of the larva or the nymph, all the others completing their full span of life without serious accidents.

In the course of its existence the cyphocrania always seeks the topmost branches of trees; after a few acrobatic exercises befitting its tender age it may be seen to take its stand on the top of a stalk; if it is alone it contents itself with contemplating the limited area spread before its view; at times, also, it amuses itself by extending its different organs in a sort of irregular gymnastics, but if one of its companions dares to approach its fragile support the combative instinct is roused and a Homeric battle is waged. Attaching itself firmly by the hooks of the rear legs to the petiole or the ribs of leaves, the insect makes use of its two long forelegs as weapons. These serve as vigorously and rapidly wielded clubs, while at the same time the head is in a state of violent agitation; the adversary is generally quite capable of warding off the blows, most of which fall wide, but some hard blows are landed and the weaker combatant must give way before the stronger. It is fortunate if the fight does not end in the loss of a limb by one of the combatants; when this happens, curiously enough, it is not due to any act of the victor but it is because the vanquished breaks his own leg in order to escape from the embrace of the enemy.

Here we have a distinctive characteristic of the cyphocrania. Autotomy seems second nature to it, and when too many insects are together in one cage it is very rare to find any of them absolutely intact. When changing the food it is necessary to pick up the little larva with infinite precaution, especially if the legs are firmly hooked to a leaf or a branch, and wait until it is ready to come of its own accord into the hand which touches it. This waiting is often very long: the larva turns its head in every direction, even to the rear, before deciding, puts forward one leg and then another, withdrawing the first; it is then that patience is necessary, for if one forces it ever so little it entirely withdraws, leaving in one's fingers the leg that one has touched. It is true, as has been so well demonstrated by M. Bordage, head of the experimental department at the Sorbonne, that these legs always grow again when the insect is in the larva state; but in this case they have only four rings in place of five, and while the member grows in the different moults it never equals the opposite member in size.

After the promenade or the battle each insect hides under the foliage during the entire day. When at repose the head is tucked in the folds of the anterior thighs where it fits closely, and the most violent noise occasions no movement either of head or of body; one might think oneself looking at a new branch laid on top of the others, so perfect is the resemblance, but when twilight falls matters are different. This is dinner time for the cyphocrania; it then takes a very different position, one imposed upon it by the conformation of the head. The table is ready laid, the tenth part of a blackberry leaf being sufficient for a new born larva; later it will require a whole leaf, and in the adult stage two or three of the biggest leaves will hardly satisfy it, for the cyphocrania is extremely voracious. When firmly attached by the hind legs to the branch which supports it, it draws toward itself the leaf it desires by means of its forelegs; the feelers which appear to be the organs of sensation, of taste and of touch, hold the upper part of the leaf vertically in front of the mouth and the repast begins; the head, which is then held very high, with the antennae gracefully curved over the thorax, describes upon the leaf being eaten a very regular arc of a circle. This head, which is thicker than the rest of the body (Cyphocrania means thick-headed, literally) has rounded edges, and its aspect is so extraordinary that it instinctively inspires my visitors with surprise and fright, especially when the insect turns it from right to left with a wide-open mouth. The head is oval and of a rather dark green, sometimes spotted with dark brown in front; the fore part of the head slopes backwards; the eyes which are prominent, display a beautiful green reticulation striped with brown lines and are placed in front and at the side; the jaws are quite powerful and can be widely separated; at first sight one could hardly imagine the strength of each jaw, and they must be examined separately in order better to understand their action. The first thing noticed is a rounded upper lip, capable of moving up and down, which covers the top of the mandibles; the latter, which are very powerful, have their inside rim deeply serrated, and the muscles by which they are moved give them a formidable appearance. The mandibles move up and down, one upon the other, cutting the foliage like a punch; the insect swallows the piece of leaf without appearing to triturate it. The lower lip bears two small organs; these consist of rather large thin membranes and are pale green in color, terminating in a black point; when these organs meet the upper lip the mouth is completely covered.

The four feelers, considered by de Serres to be the seat of the sense of smell, are in a state of continual agitation. The labial feelers having three rings, are inserted on the side of the lower lip and frequently display a very rapid tremor, while the rest of the body remains absolutely motionless. On the inside of the mouth above the lower lip there is a small membranous



Cyphocrania in the fully developed stage. The mature insect measures 33 centimeters over all, and its abdomen is 5 cm. in circumference

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projection which some former investigators took to be a tongue, though the form is very ill defined. Between the prominent eyes, which are covered with a reticulation, and the root of the antennae I discovered, upon close examination, three small smooth eyes or ocelles, arranged in the form of a triangle; being of the same color as the cranium they easily escape the view of the superficial observer. When placed under the microscope they gave the impression of a glistening substance, irregular both in form and in structure, with certain portions greener than the rest; the two posterior ocelles, which are somewhat higher than the rest of the head, are hollowed out at the top in the form of a small funnel and reflect the light by reason of their transparency. What purpose do these organs serve? It would be interesting to seek the answer to this question, the more so since they are almost invisible to our eyes and it is impossible, therefore, to consider them a mere ornament.

On turning to examine the Cyphocrania in the perfect state I noted particularly the special differences which distinguish the living specimens from those found in our collections or museums. The filform antennae have twenty-six rings in the male with a total length of 65 mm., while the thirty rings possessed by the female do not exceed 55 mm.; while walking these antennae are in constant motion and lend a most graceful aspect to the bizarre gait of the insect. At times the Cyphocrania apparently endeavors to find out what obstacles might check its advance by touching the latter of one kind or another with its antennae. By way of experiment I have touched an antennae very lightly; the insect immediately reared its head and turned on every side as if to detect some possible danger before continuing its promenade; but when I repeated the touch it immediately took refuge under a branch or a leaf in order to protect itself from all danger by its mimetic faculty.

Strikingly curious in formation as the head is, the corselet is quite as original in design; it is of a beautiful green color sprinkled with small protuberances of a much more brilliant green; these, which resemble little beads, are nearly always symmetrical and are ninety-six in number, being arranged in lengthwise parallel lines; after the death of the insect these protuberances become absolutely dull, losing all their brilliance.

Contrary to the opinion of the author of the *Encyclopédie Methodique*, the corselet has a very rounded form on the upper side and is but slightly convex beneath. In the females the circumference is 30 mm. at the mesothorax and 55 mm. at the metathorax; the prothorax, which is a little bit shorter than the head, has an almost semi-circular depression placed nearly in the center and not extending beyond the disc; it varies greatly in design in different individuals although the predominating color is a more or less dark brown; certain green protuberances are quite numerous upon the mesothorax but are rare upon the methThorax.

The abdomen, which consists of nine rings, is enormous; in the adult insect it is sometimes as much as 13 cm. long, and it is 5 cm. in circumference when not fecundated; during fecundation the presence of a large quantity of eggs considerably enlarges it; the openings of the stigmata can be clearly perceived on the sides of the rings, and the very regular movements observed enable us easily to follow all the phases of the active respiration.

At birth each segment is separated from the one next it by a red line, which gradually disappears in the successive moults, being replaced by a light brown band marking the incision. In the larval state the insects live precisely as they do in the perfect state; but contrary to the opinion of Stoll they do not grow continuously and progressively; they increase a little bit in girth only between moults without getting longer, at least very perceptibly; at first, they appear to have no wings, the latter being observed only about the time of the third moult, and at that time in the perfect state, except that they require from 30 to 35 minutes to reach their full development. The elytrae or wing cases cover only a small portion of the wings; they are 45 mm. long in the females and are very variously colored. When the insect is disturbed while at rest it spreads its wings widely, and by means of their rapid friction against the wing-cases produces a buzzing noise which can be heard at a distance of several meters; this is the explanation of the noise which is sometimes heard proceeding from the cage, a noise very much like that produced by the rapid tearing of a piece of cloth.

The male flies often and easily; its flight is much lighter than that of the dragon fly and also less jerky; unfortunately both its wing-cases, and still more its wings, were often damaged in my insectariums, either by catching on thorns or twigs in passing through the branches, or because being exposed to air, which is not renewed often enough, the external agents of destruction, such as mold and humidity, take more effect upon them, and this is a great pity since during flight, the beauty of the coloring is infinitely increased and varied by the mingling of the brown, green and yellow tints. I never succeeded in observing a female in the act of flight. I frequently made the experiment of throwing them in my courtyard to a height of several meters, but they always tumbled rather heavily to the ground, opening their wings which acted merely as a parachute; however, such an accident never seemed to injure their health. The muscles by which the wings are attached are as strong as the leg muscles, which is very strong indeed, but the enormous length and thickness of the abdomen seem to prevent the unfortunate creature from making use of its wings to rise in the air, and even force it to walk rather slowly.

From the month of August, 1914, until the same month of the following year I had the opportunity of observing an uninterrupted cycle of hatching, moulting, the coupling of perfect insects and the subsequent deposit of eggs. Every day a few new individuals appeared to reinforce the colony; the insects hung suspended one from another in clusters like bunches of grapes; the various moults, too, which commonly place the Orthoptera at the mercy of all their neighbors were nearly always disastrous.

This phenomenon of moulting being exactly similar in the Cyphocrania to that of the PhyHia, of which I have spoken in a previous article,[1] I shall not here describe it; I would merely note the extreme delicacy of the insect at this period of its existence. I have lost a great many specimens because the narrow quarters in which they were confined do not permit them to isolate themselves, hence their teguments were torn while in the process of transformation by their companions while the latter were taking their nocturnal rambles. It is necessary, therefore, to give them as much space as possible in a number of shelters in order to rear them successfully; sometimes, even, surgical intervention is of advantage and produces valuable results.

One evening a nymph was assuming the adult form when the head in emerging from its envelope became wedged between two branches and arrested in its development; form one leg, which had been broken at the end by the thorns of the blackberry, issued several drops of a green liquid. Thereupon I ligatured the broken leg with a little piece of thread, gently disengaged the head and cut away the neighboring branches, assisting the insect at the critical moment to a complete recovery, so that it developed without interruption.

Some authors pretend that the larva and nymph of the Orthoptera cease to eat at least two days before undergoing their transformation; the fact thus generalized is greatly exaggerated, for I have often observed that the Cyphocrania do not refuse to eat even only a few hours before moulting.

On September 5, about 5 o'clock in the evening, I was agreeably surprised, upon opening the door of the insectarium, to hear a softly modulated stridulation in the midst of the foliage, an attenuated stridulation, but very similar, nevertheless to that produced by the cricket of our fields in the warm days of summer. I spent a long time trying to find the author of the sound, but my efforts were without success that day, for the movement of my hand among the foliage frightened the insect and the sounds instantly ceased. The next day I again opened the door of the insectarium, but with the greatest precaution; I quickly heard the same noise, and clearly perceived the female insect which was producing it, but it was impossible to recognize the organ in operation; neither the wing-cases nor the legs showed any perceptible movement; only the feelers were gently agitated and I could not discover whether this stridulation, which was truly singular, proceeded from these organs, which appeared to me hardly possible.

Instinct in these animals, as in the rest of the Phyllia, is very rudimentary; they are quite lacking in initiative, which explains why it is necessary, when rearing them, to make frequent observations of the cages. For example, it is the habit of the insect to ascend to the top of the branches and devour the upper leaves. When these are gone while the lower twigs are still covered with tufts of leaves, do you think the insect will descend to satisfy his hunger where there is an abundance of food? Not at all! It will climb as high as it can and run all around the cage searching for the absent foliage; if I then seize it, it lets itself fall heavily, and climbs up the branches till it regains its first position without stopping; it must be really starving before it will remain upon the lower leafy branches.

[1]See *Rev. gén des Sc.*, October 15, 1916, vol. xxvii, p. 550 and following.

The predominating color admirably imitates the green of blackberry stem, but it would be erroneous to suppose that this coloring is uniform in all specimens; on the contrary, each individual differs from its companions by certain special designs which disappear after death. Some of them have black lines scattered over the bodies, the legs, the lamellae of the abdomen, and even the head; in others the general tone is enriched by red dots on the slides of the abdomen; at the point where the legs are attached some of them have distinct spots of a very beautiful black, but it is a very remarkable circumstance that if a design appears on the thorax the same design will be found on all other portions of the body; each individual differs from every other, but remains perfectly homogeneous in itself.

The mimicry in the larva is perfect; it exactly resembles the stalk which supports it; because of this whenever the foliage was changed a few insects, stiffened by the cold, were always to be found among the branches thrown outdoors.

The males differ markedly from the females, both from the biologic and the morphologic point of view; they develop more rapidly than their mates and often reach the adult stage before the latter, either because they undergo only seven moults while the females have eight transformations, or because these transformations succeed one another more rapidly in the case of the males. However, it is difficult to count upon a constant number of transformations; a mutilation which causes a serious effusion of blood diminishes the number of moults. In such a case the penultimate change is lacking, and the larva passes immediately into the state of the imago; in other words, there has been a suppression of the nymphal stage.

The larval and nymphal state lasts in general from four to five months, but greater continuity and intensity of heat considerably advances the period of the transformation. When the male has attained a perfect state his duration of life is from three to four weeks; this is the period of procreation and in this state he very rarely eats. The female, on the contrary, who is destined to perpetuate the race, prolongs her domestic and maternal life for from six to seven months. While the vitality of the male is comparatively feeble that of the female surpasses the wildest flights of the imagination.

A striking example of this is the case of a magnificently colored female which I desired to preserve intact in my collection: I placed her in a vessel containing cyanide of potassium and allowed her to remain immersed in this atmosphere for three hours, at the end of which time she appeared to be quite dead. I then entirely removed all her internal organs, leaving only the skin, which had become almost transparent; I then took great care to cleanse the head with a tampon of cotton wadding; finally the legs were subjected to strong pressure until all of the green liquid contained was expelled. I stuffed the skin with a thick piece of cotton in order to preserve the insect in its primitive form and then spread her out. This took place about 9 o'clock Monday evening; the next morning this female was still living; it was necessary to replace her in the dish of cyanide and spread her out again. I repeated the operation with two new specimens, taking the minutest precautions and with fresh cyanide; the result was identical and on the morrow both insects were still living.

Certain facts in the life of these orthoptera lack any sort of plausible explanation: for example, everything is quiet in the insectarium, not a movement is seen, not a sound is heard, when suddenly, without any apparent reason, a larva or a nymph begins to thrust its legs hither and thither with the utmost violence; the whole body is agitated by a febrile tremor which rapidly increases in violence; it consists of a vibration of the entire creature, a sort of extravagant dance, whose meaning is incomprehensible. This agitation quiets down after four or five minutes, without the animal having changed its place.

The manner in which the Cyphocrania deposit their eggs is precisely like that of the Phyllia; at the proper moment a rapid movement of the abdomen from front to back is produced, and the egg is projected to some distance among the foliage, or perhaps strikes violently the glass wall of the insectarium; however, it suffers no injury, for its thick envelope is capable of sustaining a strong shock without breaking, and its close resemblance to certain seeds readily hides it from the sight of its enemies. A single female lays from twelve hundred to thirteen hundred eggs and each insect, especially when adult, is extraordinarily voracious, which facts throw some light upon these remarkable Orthoptera from the agricultural point of view.

Organic Matter and Life*

Light Thrown Upon Life Processes by the Study of Connective Tissue

By J. Nageotte, College of France

THE concept "life" has retained a mystical signification, in the thought of many scientists, which in my opinion constitutes more or less of a hindrance to progress. Even those investigators to whom we are indebted for progress in the science of morphology, do not always escape the influence of the doctrines of the vitalists. Virchow, for example, to whom we owe the completion of the cellular theory, and also its dogmatism, said in 1858 that neither the "solid intercellular substances" nor the liquid intercellular substance of the blood could be considered to be the seat of life; however, he felt obliged to admit that there persists in them "a reminder of living activity which they derive from the cells, from which and by means of which they have their birth; but no certainly known fact proves that this remainder is great enough to be preserved intact without the permanent action of the cells." According to this view therefore, life, a mysterious property belonging to the cells, may be diffused and may become temporarily attached to substances which are not living matter in themselves: each cell is charged with maintaining life within a certan area surrounding it, which Virchow calls a "cellular territory." More recently certain famous theories have been propounded which are inspired by a vitalism no less vague.

Nothing could be more legitimate than the idea that there can be distinguished in "living matter" certain anatomo-physiological units, the cells, which are capable of surviving when separated from the medium by which they are surrounded. It is also easy to accept the idea that there are certain "organites" in the interior of the cell which appear to play a peculiarly important part in the life of the cell without always being themselves capable of living when isolated, at any rate under present conditions.

But it would be dangerous to proceed further along this path. The molecule of our tissues has no right to the designation "living molecule." Between this molecule and the typical elements of the protoplasm which are perceptible to the sense of sight, there exists an entire hierarchy of intricately united structures of an increasing degree of complexity. But in how far is it possible to say that life is "inherent" in any individual particle within this hierarchy? To give the hypothetical name of *gemmule, pangene, biophore, plastidule, or protomere* to such a living particle teaches us nothing; and neither does it get us a step further to say that the nuclear and the protoplasm are formed of colcodules and of plasmodules.

In reality our concept of "life" consists of disparate elements. It may be disintegrated into a certain number of qualities all of which are not necessarily found in combination, and none of which has in itself any specific value.

When the life of an individual is concerned our ideas on the subject are very precise; but they are entirely dependent upon their combined signification. In proportion as we go deeper into scientific analysis the concept "life" becomes disintegrated and progressively loses its significance. When we reach a certain point it is far preferable to discard it rather than to create a new mythology by the illusory personification of its attributes. The *isoplassonts*, the *autokinconts*, the *automerizonts*, the *idioplassonts* are so many Kobolds which should be excluded from our minds. Our only guides in the study of the relations which exist between life in the general sense of the word and that which we call organic matter or organized matter, should be microscopic observation and experimentation and the freer these are from all metaphysical trammels the more fecund will they prove to be.

It is our purpose in the present article to seek to discover how far such researches based upon morphology can be logically carried in the present state of our general information.

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In seeking to discover what life really is we will take as our point of departure the analysis of a tissue which we know to be a living tissue. Intermediate as it is between the life of the cell and the life of the individual, the life of the tissue is sufficiently complex to permit us to attack the problem without narrowing its limits and yet sufficiently simple to retain that definiteness which belongs to it when viewed as a whole.

Starting with the tissue it is easy to descend towards the living unit, the cell, or on the other hand to ascend to the internal milieu which is the property and the essential characteristic of the individual.

*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT.

Among the various tissues the one from whose study we can hope to gain the most, is the connective tissue, in which there are found in great abundance those "solid intercellular substances" whose living activity was ascribed by Virchow to the influence of the cells which it contains.

The connective tissue is constructed of an abundant "felting" or matting together of fibres; its meshes are saturated with a serous substance which is constantly renewed and forms a part of the internal medium, and among the meshes there exist cells often in considerable numbers. The contrast between these two constituent elements of this tissue is very great. On the one hand we have the scattered cells formed of protoplasm and containing a nucleus and certain granular bodies; on the other hand we have the filamentous substance which is continuous and which does not possess the granular structure that is an essential characteristic of protoplasm. There has been a great variety of opinion as to the vital nature of this intercellular substance. Before the triumph of the cellular theory it was regarded as a remainder of the blastema which had not been utilized in the making of the cells. Then it was believed that the fibres resulted from a transformation of certain cells which have ceased to be living and have preserved merely a mechanical rôle. Some authorities have thought that it was a secretion, i. e. a nonliving substance. But the theory most widely accepted at the present time, and existing in a number of variants, is that of the exoplasm.

The whole intercellular apparatus, which is very complex, is derived, according to this theory, from successive differentiations of the exoplasm, i. e. the peripheric portion of the cellular protoplasm. The first differentiation gives birth to a substance having a homogeneous aspect and known as the *fundamental substance*. This substance is formed in reality by a very delicate felting, the "weft" (*tramule*) of Renaut, within this fundamental substance, and is formed at its expense; a second differentiation causes the appearance of *connective fascicles* or *collagenes* which are themselves formed of *fibrillæ*, having a very complex structure, and of *elastic fibres*.

We have here, therefore, organic matter which has evidently been formed under the influence of pre-existing cells, but which has acquired a more or less complete degree of independence. It grows by intussusception, assimilating the substances which it requires. It shapes and adapts itself to local conditions without being influenced therein by the cells which gave it birth; rather, indeed, it impresses its own form upon the cells which reside in it. Here it is arranged in the form of tendons, therein aponeuroses, elsewhere still in the loose cellular tissue which favors sliding movements; in a word it is everywhere so disposed as to conform to local needs. Laguesse, who has made an extensive study of the fascicles, puts the following query: "May we not assume that the fundamental substance when once formed, even though it may remain more or less dependent on an adjacent cell, is capable of having a life of its own, though this may be less intense than the life of the cell?"

The matter may be carried still further. V. Ebner, starting with the surface of the dorsal cord in the embryo of the *Selachii*, has demonstrated that the substance of the connective tissues shapes itself into a very complicated structure forming the sheath of the cord, in which there is no cellular element properly so called. But at a given moment certain barriers are broken down and the adjacent connective cells instal themselves in this abode which has been previously constructed and completed as though specially designed for them. How can we help believing that a substance which grows and shapes itself in this fashion with so sharply defined an autonomy is itself a living thing?

* * *

When we turn our attention to other objects of study the question undergoes a singular change of aspect.

While observing the evolution of scars I became convinced that the reticula of fibrin which appear in the first phases undergo a direct transformation upon the spot into fundamental substance. The felting becomes populated with connective cells which have immigrated thereto and we then behold the arrangement and the characters of the filaments of fibrin undergo a progressive modification until they come to resemble by insensible degrees the arrangement and the characters of the filaments of fundamental substance. In histological sections, in which the fibrin and the fundamental substance take on different colors, it is easy to follow step by step this transformation, which is accomplished without our being able to perceive any given moment a phase of intermediate decoagulation. We are not dealing here with a substance which disappears in order to give place to another, but with a substance which is being actually metamorphosed.

Later, and by an identical process, the fundamental substance thus formed is transformed into connective fascicles. Its fibrillæ, which are at first unoriented, group themselves progressively in parallel fascicles at the same time that their characters undergo a change. Here again the felting reshapes itself without any perceptible decoagulation.

In short the fibrous tissue in which this series of metamorphoses results is identical with that which is formed normally in the embryo where the fundamental substance appears in the beginning without being preceded by a fibrinous stage. We may conclude, therefore, that the fibrinous stage is not indispensable, but its presence in certain pathological processes throws a strong light upon the essential nature of solid intercellular substances.

At the very time when my study of the formation of scars led to the above mentioned results, my conclusions had already been confirmed in a work by Baitsell, a student under Harrison, which had appeared a few months previously; I knew nothing of this work until after the publication of a report presented by me to the Society of Biology; consequently the facts it contains exerted no influence upon my observations, and the two sources of information are entirely independent of each other. The American author has shown that in cultures of the adult tissues of the frog the fibrin of the plasma is often transformed upon the spot into a dense felting of fibrillæ oriented in fascicles which reproduce or imitate the characteristic form of connective tissue. Doubtless the histological characters, to judge of them by the descriptions given by the author, do not reproduce the arrangements of connective tissues except rather remotely, but this remoteness is a necessary result of the differences which exist between the conditions of life in a tissue growing in a culture and those in a tissue which is merely injured but remains in its proper place in the organism.

As a matter of fact Baitsell's observations signify the same thing as my own and permit the same conclusions.

We may state the resultant generalization, therefore, without lengthy dissertation as to its legitimacy, in the following words: *Intercellular substances are formed at the expense of the albumens of the internal medium and their formation is intimately connected with the process of the coagulation of the fibrin.*

The fibrin coagulates under the influence of a special ferment known as fibrin-ferment which operates under complex conditions in which the salts of lime play a necessary part. Later a second substance formed by the blood corpuscles plaquette acts upon the clot formed and causes it to contract, as has been proved by Le Sourd and Pagniez. These observations show that the formation of the intercellular substances belongs to the same series of phenomena, of which it forms merely a continuation. The mysterious influence of the cells upon the "life" of these substances is nothing more therefore than the action of ferments acting outside the cells which secreted them.

The very remarkable autonomy of the solid intercellular substances, which helps to give them the appearance of an independent life, results from the multiplicity of the factors involved in their appearance, their development, and their adaptation to surrounding circumstances. The mechanical forces to which coagulation is so sensitive particularly insure the orientation of all the parts of the structure.

Thus we may regard the organization of the albuminoid substances as a higher degree of coagulation, and the coagulation into fibrillæ becomes one of the principal factors involved in the structure of tissues, and consequently in the general morphology of living creatures.

In 1882 Rauchenbach of the school of Alexander Schmidt, having found a coagulating ferment in the sperm, raised the question as to whether this ferment is not the point of departure of the entire process of ontogenesis; doubtless the part played by a "primordial ferment" has not been demonstrated, but the action of coagulating ferments in ontogenesis is none the less certain.

The great importance of coagulation in the develop-

ment of the egg was thoroughly comprehended by Yves Delage and it was this idea in fact which led him to make his celebrated discovery of experimental parthenogenesis. And Bataillon in his turn demonstrated that in this artificially excited ontogenesis the action of diastases is necessary.

Coagulation of the fibrinous type is due to the fact that in certain complex conditions the molecules or groups of molecules of albumens arrange themselves in rows and then in networks or reticula. It is natural that mechanical forces should exert a considerable influence upon the arrangement of the filaments and also upon the formation of the clot; everyone is familiar with the effect produced by beating or stirring in the coagulation of the blood and also by the nature of the surfaces of contact. We have here the rudiments of what is known as irritability or excitability whose significance will become clear further on.

But the most remarkable property of the clots from the morphological point of view and the one about which least is known is that property which enables them to entirely alter their structure by simple molecular displacements without perceptible decoagulation. Unlike the feltings *feutrages* which we handle daily, those which result from coagulation are eminently unstable, therefore, in spite of their apparent solidity.

The experiment devised by Hardy gives us an interesting example of this. By a rather complicated process in which the salts of lime play an important part we are able to cause the appearance, in a colloidal solution of the white of egg, first, of a cloud, and then of filaments which arrange themselves in the form of an open network or reticulum. But equilibrium has not yet been attained and this network soon contracts and becomes transformed into a typical closed reticulum with thickened nodes. We have here merely a rudimentary example of a phenomenon which in other circumstances and with different albumens produces results which are infinitely more complex; but what makes this example very instructive is the fact that it is also possible to obtain by more simple processes geometrical crystals of this same albumen of the egg. We must conclude, therefore, that the process of coagulation into filaments and into reticula is a phenomenon which is distinct from that of crystallization, in spite of its being due to molecular forces. Only, coagulation leads to organization, of which it is merely a lesser degree.

These ideas quite naturally suggest the theory of a general plan of organization of the living creature, which at each period of its development would be indicated by the perimeters of diffusion of the ferments secreted by the cell and poured forth into the internal medium. Such a plan would undergo a constant evolution according to the modifications produced in the permeability of the substance by the coagulations successively effected.

The internal medium in which these phenomena take place receives the substances furnished by the food of the living creature; it is nothing more than a meeting place of those substances which are necessary to life and of those which result from the vital activities. Doubtless many chemical transformations and reconstructions of molecules temporarily broken up take place in this medium much as they take place *in vitro* in a medium which is chemically similar, though artificially reproduced.

Within this general internal medium there will inevitably be established distinct areas or territories constituting local internal media in relation with the perimeter of diffusion of the cells and groups of cells. But the phenomena of the coagulation and the elaboration of clots which terminate in the construction of an abode which is suitable for the needs of the cellular elements, are necessarily closely connected with the chemical and physical phenomena which take place within the interior, or at the periphery, of these perimeters of diffusion. The result of all these reactions is a complicated structure which, while retaining its uses as respects the cells, must also by reason of its sensitiveness to mechanical influence shape itself according to the needs of the individual, of which it constitutes the framework or the skeleton.

What becomes then of "the life" of the intercellular substance in this ensemble? We can have no further difficulty in estimating the exact value of each of its attributes: namely, the "automaty," the faculty of assimilating and growing by intussusception, and, from the anatomical point of view, the organization of the materials of which it is composed. Furthermore, we have been able to prove the entire absence in the intercellular substance of two attributes which remain the property of the cell: namely, the power of making syntheses at the expense of simpler compounds, and also the necessity which each morphological unit is under of undergoing its birth by means of the division of a pre-existent similar unit. We shall soon have occasion to discuss these latter attributes.

If we frankly abandon all preconceived ideas which are foreign to the pure and simple examination of the facts, we must look upon the connective substances merely as the abode of the cellular elements and we shall naturally be incited to make experiments to find out whether this abode is capable of receiving other occupants when the original ones have been removed. Let us kill the cells therefore by fixing a fragment of connective tissue, a tendon, for example, with alcohol, formol, or even with sublimate and then replace this fragment in the organism; in other words let us make a dead graft.

In this case we shall have the satisfaction of proving that the fibres of this tendon, far from being phagocyted, i. e. devoured by the white blood corpuscles, persist in their form and attach themselves to the connective "weft" [trame] of the host; later we shall observe the dead cells being carried away by the leucocytes while other connective cells emigrate from the tissues of the host and come to take their places.

At the end of a few weeks the dead graft has become living once more because its cells have been replaced and because its connective tissue, not being living in the ordinary sense of the word, could not be killed. And if we know the proper thing to do we can even oblige this resuscitated tissue to grow, the better to prove its recovery of vitality. Its connective substance will then increase in volume, new fibres will be formed in it, and it becomes no longer possible to distinguish in its mass the grafted substance from that which was added later in the course of its growth, for this growth takes place by means of intussusception, according to the normal method. However, no substitution has taken place: this is the very graft which we introduced, and its anatomical characteristics have persisted in spite of the evolution which has been produced in it.

And this remains true even when the graft is heterogenous; for example, when the graft is taken from a calf and grafted on to a dog.

The revivification of the tissue is complete, therefore, and the theoretical concept which inspired us to make this experiment is completely confirmed.

* * *

Taking these experimental bases as a point of departure we can now carry our process of reasoning still further in the same direction; naturally, however, it becomes more and more hypothetical.

The cell is constructed upon the same type as the entire organism, though it is of a different order of magnitude; furthermore, the single cell can be studied in the unicellular living creatures.

The *nucleus* and the *granula* of Altmann, or the mitochondria, as these bodies are now generally called, represent the cells of the tissues. The *intergranular substance* is analogous to the intercellular substance; the *cellular juice* plays the part of the internal medium.

Many facts tend to prove that the intergranular substance is a felting or network of filaments like the intercellular substance, and that consequently its mode of formation is the same; all which we have said concerning the "life" of the intercellular substance can also be applied, therefore, to the intergranular substance. Specialized fibrillæ become differentiated in this intergranular substance in the same way that the collagene and elastic fibres become differentiated in the connective fundamental substance; I have reason, in fact, for believing that these fibrillæ are not directly derived from the mitochondria as so many authorities believe.

Among the fibres thus differentiated, which may constitute several distinct systems in a single cell, certain ones have merely a mechanical rôle, as in the case of the epithelio-fibrillæ which have been recently extensively studied by P. del Rio-Hortega. Among this class of fibres of support there are some which while intracellular to a certain extent afterwards mingle, outside the cell, with the intercellular feltings, like the neurologic fibres and the fibroglia-fibrils of Mallory; these establish a transition "tressing" [armature] of the protoplasm and of the tissue. The adhesion of the telophragms to the sarcolemma in the muscular fascicles has the same significance, for the telophragms belong to the protoplasmic coagulum and the sarcolemma must be placed in the category of intercellular substances.

Certain other fibrillæ are charged [accaparent] with the motor function which pertains also in a lesser degree to the non-differentiated "weft" of the amœboid protoplasm. The conctractile fibrillæ, whether more or less highly specialized constitute motors capable of transforming into mechanical labor, by processes which remain to be determined, the chemical energy furnished by the substances which are elaborated in the granula.

Still other filaments, finally, the neuro-fibrillæ become the organs of the nervous function, exhibiting their quality of excitability under the influence of various phenomena.

According to our present hypothesis, therefore, the excitability of the protoplasm, i. e., the appearance in it of reactions which are related to its sensbility to external agents, is by no means a phenomenon which is essentially vital, but is, on the contrary, simply the manifestation of certain physical properties connected with certan molecular groupings. The rudimentary excitability which is detected in the course of the formation of the fibrinous clot is merely a first sketch, so to speak, of functions, which when supported by more complex substances, are destined to become the most remarkable attributes of life, such as our ordinary ideas conceive the latter to be.

After making all these various eliminations we find ourselves confronted by particles in which the very essence of life, that mysterious property of the tissues, seems at first glance to take refuge: namely, the granula, to which Altmann gave the significant name of *bioblasts*, but which are at present better known as mitochondria, and the nucleus.

The mitochondria, which in themselves are immobile or nearly so, have an external form which is extremely simple, contrasting strongly with the complicated nature of the framework of the cells and of the tissues; but their chemical constitution is more complex, for they contain lipoid substances, as has been proved by the researches of Regaud and of Mayer, Fauré-Frémiet and Schaeffer; these are lipo-proteic complexes. While almost liquid they appear nevertheless to possess a complicated texture which cannot be directly perceived by reason of their extreme smallness of size, but which is supposable, judging by the myeline sheath of the nervous fibres, which is probably simply a mitochondria of exceptional form. As for the nucleus the complicated nature of its structure is evident.

More and more these particles appear to us to be centers of chemical activity in which are elaborated by means of synthesis, starting with simple inorganic compounds, all the substances necessary to the construction and to the life of the individual. But this cannot be accepted as the exact truth except by taking into consideration the whole ensemble of living creatures, for all the different kinds of protoplasm are tributary to each other, by way of the internal medium of the individual and by means of the alimentation throughout the series of organisms, from the bacterium which fixes nitrogen, up to the nerve cell, which has need of the most intimate collaborations in order to maintain its existence. The plants can make direct use of solar energy, which enables them to elaborate not only all the substances required for their own life, but also to lay up stores of chemical energy; thus they are enabled to furnish the latter even to animals, which use it almost exclusively—we could not exist without the immense surface of the leaves of plants. These also furnish certain products which are indispensable to animals, and which the animal mitochondria are unable to make.

In all these transformations of matter we can perceive naught but the effects of energy, acting by physical and chemical processes and nowhere requiring the intervention of "vital forces." The only point to which mystical preoccupations can still be attached is that which concerns origins. Altmann has extended Hawey's axiom to the granula, saying *"omne granulum e granulo"*; he appears to be correct, though the fact has not yet been proved for the mitochondria as it has for the nucleus. Thus the cell may be looked upon as a zooglea of microbes originally free which have acquired the habit of a common life. By bringing the nucleus into this association it may also be compared to the symbiosis of which the lichen is a striking example. The essential point is that the component parts have their birth in the actual or habitual conditions, in the division of pre-existing similar elements.

A similar negation of spontaneous generation is practically the basis, though theoretically the weak point of the Pasteur doctrine. But these questions lie outside our present bounds and we must confine ourselves to defining the conclusions arrived at in our present study.

* * *

The organization of matter, wherever we have been able to perceive its mechanism can be recognized as due to the action of multiple factors, none of which exhibits a "vital" character when taken alone; life results from the interplay of the physical and chemical properties of this matter, under the conditions of molecular arrangement due to its organization, a circumstance to which its full weight must be given. No particle is *living* in itself, but the attributes of life multiply in proportion as the organization becomes more complex, and as the relations between the parts successively differentiated become more numerous for that very reason. At the base of the organization there are found certain primordial groups where there are established the chemical reactions by means of which the material necessary for the construction of the living creature are elaborated, together with those substances which enable it to maintain its structural activity.

The Races of Russia*—I

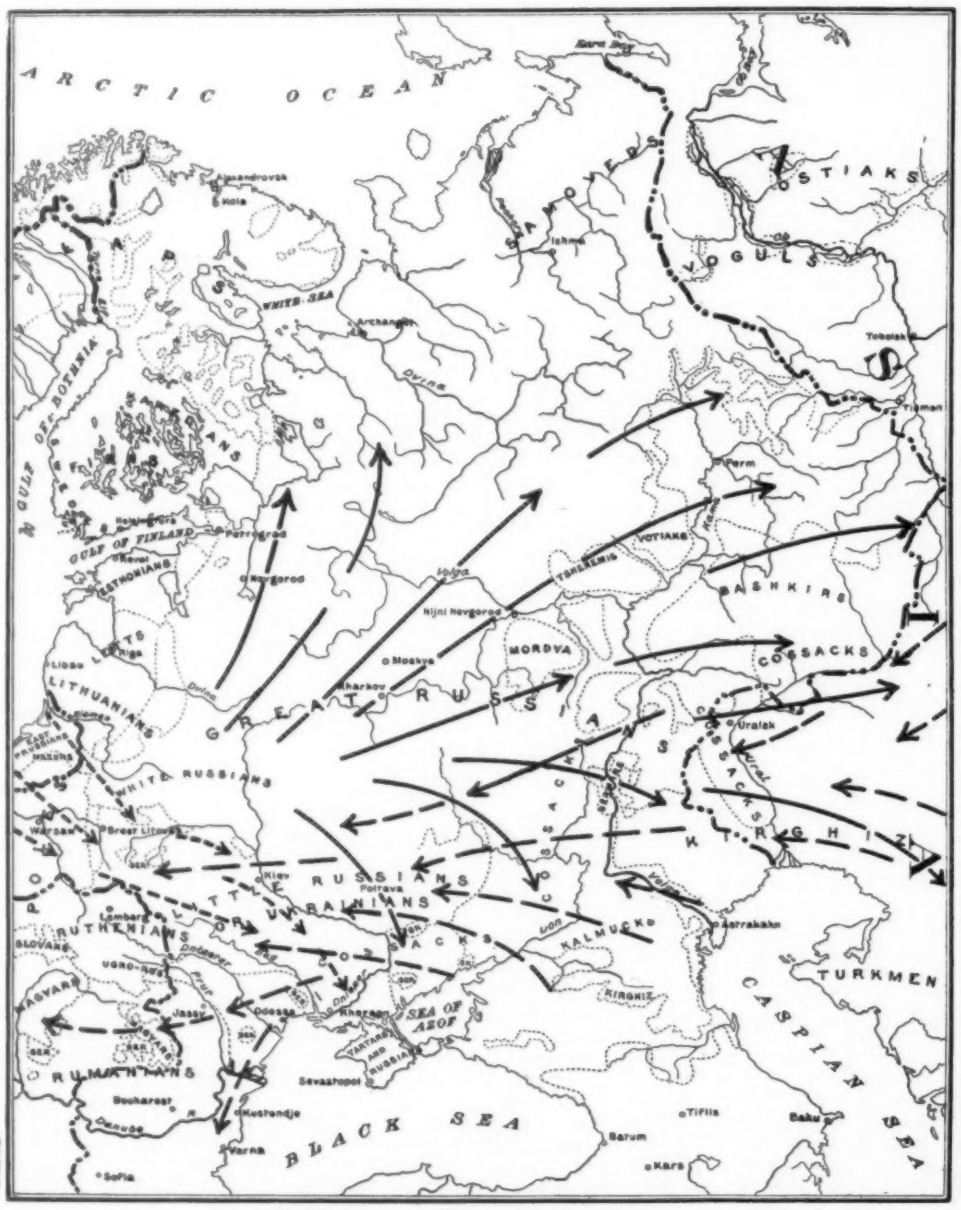
A Brief Outline of the Ethnic Background of the Czar's Former Domain

By Dr. Aleš Hrdlička of the U. S. National Museum

THE subject of the races of Russia—the great Russia that was yesterday and that must be again if the world is to know any peace—seems very baffling, and is in fact far from simple. Yet if the field is viewed from a higher horizon, with due historical and anthropological perspective, many of its irregularities disappear, and where at first there seemed to be an almost hopelessly involved mosaic of ethnic differences there are seen great areas of fairly uniform racial color.

So far as known to science, European Russia began to be peopled during the latter phases of the paleolithic epoch and the following neolithic times. Some skulls found in Russian Poland and southwestern Russia show features that still remind the anthropologist quite strongly of those of the Neanderthal man, but on the whole the type is already fairly modern. The remains from these earlier times are, however, still rare and limited to territories into which extension from the more southern and western parts of Europe was easily practicable.

A much more important peopling of European Russia took place during the latest neolithic, and the bronze and iron periods; and it proceeded, as far as is now discernible, not only from the adjacent regions in Europe, but also over Caucasus and from the great steppes of Asia. The western Asiatic or Ural-Altaic elements, evidently quite early and numerous, overran and sparsely settled or roamed over perhaps as much as two-thirds of the great region of what is now European Russia, reaching in the north to the limits of the land, in the west as far as Finland, Esthonia, Livonia, and approximately the thirtieth meridian, and in the south below the latitude of Moscow. At about the same time the southeastern and southern parts of Russia became peopled by Turanian and Iranian tribes, spreading over the Caucasus and from beyond the Caspian. Only the western and southwestern parts of the great territory received the overflow from the adjoining countries of Europe. The southern grassy plains became then a broad and important avenue for a long series of movements of populations, directed principally from east to west, and the territory was gradually covered with remnants of these populations. This much is known, though the details of these earlier ethnic movements in Russia are lost in the haze of antiquity, or preserved merely in historical fragments.



HISTORIC MOVEMENTS OF POPULATIONS IN EUROPEAN RUSSIA.
——— Spread of the Slavs.
– – – – Invasions by Asiatics.
– - – - – Invasions by Nordic tribes.

The first tribes occupying part of the territory which is now Russia, with whose specific name we meet in ancient chronicles, are the Cimmerians, the people whose name is perpetuated in that of Crimea; and the Tauri, from whose name is derived that of "Taurica," the other old name for the Crimean peninsula. Our actual knowledge of these peoples is, however, very limited. Neither reached great importance. The Cimmerians, who probably antedated the Tauri, occupied a part of Crimea and the territory north and northeastward, extending to and about the Palus Maeotis (Sea of Azov); they eventually came into contact with the Thracians and possibly other European groups; but their affinities seem to have been with the Caucasus and the Asiatic countries to the southward, rather than with Europe. They are said to have eventually disappeared into the regions south of Caucasus, being replaced, possibly before 1,000 B. C., by the Scythians. The Tauri, probably of the Turanian stock and reputedly very barbarous, occupied the peninsula up to the time of the Greek colonization, after which their name gradually disappears.

This brings us to the more strictly protohistoric times of the region under consideration, the period of the Greek voyages and colonization along the shores of the Euxine (Black Sea). At this time the whole vast territory had been subdivided among various tribes.

These protohistoric populations first became better known as a result of the famous march into their country of Darius Hystaspes—the first Napoleon—about 512 B. C., and more especially through the writings of Herodotus, about 450 B. C. Of those populations that were mainly of Asiatic origin by far the most prominent were the "Scythians," whose territory embraced practically the whole present southern Russia below about 50° of latitude. Peoples of related origin covered the country from the Urals to Finland and from the Volga to Esthonia. They were subdivided into numerous tribes and differed somewhat in blood, but all belonged to the Turkish, Tartaric, Finno-Ugrian, and Laplandic subdivisions of the great Ural-Altaic stock of Asia. All the peoples, including the Scythians proper, had in common a greater or lesser admixture of Mongolian blood, many were nomadic or semi-nomadic, none being strictly agricultural, and except where in prolonged contact with other peoples, such as in the case of the Scythians with the Greeks, the Bulgars with the Khazars, or the Finns with the Scandinavians, their culture was of a low order.

The more northern and less hospitable regions were only sparsely settled, developed no native political units of importance, and played but a secondary part in the history of European Russia. The more southern of these populations, on the other hand, were much more numerous, showed greater virility, and, possibly under Iranian influence, greater powers of organization. They gave rise to the old Scythia; they constituted for two thousand years the dread southeastern background to the European peoples of Russia; and they were the sources, under one name or another (such as Huns, Avars, Turks, Tartars, etc.), of many disastrous invasions of southern Russia and even central Europe from the third to the thirteenth centuries of our era.

The term "Scythians" deserves a few remarks. Due to their warlike qualities and the direct intercourse with them by the earlier Greeks, few "barbaric" nations of the pre-Christian era have been more mentioned, and few peoples since have given rise to more speculation as to their racial identity. On the basis of our present historical and archeological knowledge it may, however, be safely said that the early Greeks applied the term Scythians not to a race, but to a mass or conglomerate of peoples, partly nomadic and partly agricultural, who occupied the southern part of Russia when the Greeks began to explore and colonize the coasts of the Black Sea.[1] The main strain of the more eastern Scythians was undoubtedly Tartar or Turkish, but probably tinged with Iranian. To the west of the Borysthenes (Dnieper), however, and particularly in present Volhynia, Bukovina, and Galicia, the principal strain and possibly exclusive element of the population from the earliest times was evidently of European extraction, and this stock could have been in the main no other than Slav. To it belonged tribes such as the "Neuri" (Nestor, the earliest Russian historian, mentions "Norici, who are the same with the Slavs"); the Alazones or Halizones (which in Russian would be Galitshani, after which Galicia); and possibly the Borysthenitae husbandmen.

The true Scythians claimed to have occupied the country in which they were found by the Greeks for many centuries. As shown by their customs described by the Greeks, and by the remains of their culture uncovered by archeological exploration, they were not wholly a barbaric people; and contrary to what may be observed with later Tartar tribes, their war-like activities were directed mainly toward Persia and Asia Minor rather than toward Europe. It was to avenge their invasion of Medea and Persia that Darius

*Smithsonian Misc. Coll., Vol. 69, No. 11 (Publ. No. 2532).

[1]Compare Ellis H. Minns—Scythians and Greeks, 4°, Cambridge (Engl.), 1913.

undertook his memorable incursion into their country. Proceeding over Hellespont and the Danube he reached as far as the "Oarus" (supposed to have been the Volga, but more probably the Dnieper), only to find his great effort against the nomads quite futile.

Scythia, which never formed a highly organized, cohesive political or national unit comparable to that of Persia or Greece, existed, with waning vigor, until the early part of the Christian era, when it gave way before the Gothic, Hun and Khazar invasions; but the name, as applied both to the country and to its inhabitants, persisted for many centuries afterward.

Scythia itself was subject to invasions, which deserve some consideration. Shortly after the commencement of the present era, there are noted in Europe, and between Europe and Asia, movements of peoples which are commonly referred to as "the migrations of races," but which in the main were invasions for conquest or plunder, or were the results of displacements, not seldom forcible, of tribal groups in regions where the density of population had surpassed the resources and the struggle for existence had become acute. They doubtless succeeded older movements of similar nature, of which we have little or no knowledge. They followed two main directions—from the north southward and from the east westward. Russia that was to be, was in a large measure the avenue over which these migrations took place.

The first of these invasions into what is now Russian territory of which we have better knowledge is that of the Goths, though some indications make it possible that these were preceded by less important offshoots from the same stock of people. The Goths were of Scandinavian origin, coming originally perhaps from or over the large island in the Baltic which still bears their name (Gothland). From this they easily traversed the Baltic, known in the early Russian annals as the "sea of the Variags" or Scandinavians, and landed somewhere on what is now the Prussian coast, in the vicinity of the Vandals and probably not far from the Vistula River. There they remained for a time; but when the number of people increased greatly, Filimer, their king, "decided that the army of the Goths with their families should move from that region," and "in search of suitable homes and pleasant places they came to the land of Scythia." (Jordanes, Getica, 551 A. D.) Whatever the details of their invasion, it is certain that by the beginning of the third century A. D., the Goths reached as far as the western parts of Scythia, to the Black Sea and the Danube, as well as to the south of the Carpathians. They then became known as the western and the eastern Goths, or Visigoths and Ostrogoths; and the latter, with whom alone we are here concerned, were found at the beginning of the fourth century ruling over the territory from the Carpathians to the Sea of Azov. This rule they kept up until 375 A. D., when their state under Hermanric, together with the remainder of Scythia, was broken up by the invasion of the Huns. Most of the Ostrogoths who survived sought refuge in the southwestern part of Europe; while those who remained were subject to the Huns until after Attila's death, or about 460, when they moved bodily into Pannonia, granted to them by the Romans.

However, the Goth sovereignty in southwestern Russia should not be viewed as an occupancy of a waste or depopulated region by a new race. The territories in question were peopled before, and remained so after the period of Goth domination. And their population was not Goth but in all probability Vendic or Slav, though there are also mentioned the Callipidae (Gepidae), the Alans, and the Herull, who may have been some of Alpine and some of Nordic extraction. The Goths were war-like northerners, who forcibly invaded Scythia in considerable force for the time, and brought with them their families. Due to their favorable original geographical position and their sea activities they, much like the Germans of today, were more advanced in culture and especially in military art and equipment, than the inland populations that so far were relatively only slightly affected by the rest of the world. As a consequence the northmen found little difficulty in overrunning great areas occupied by the sedantary as well as the nomadic primitive tribes, which had little political unity and no adequate power of resistance. Some such tribes could even be employed against others, though of their own blood, and the invader finished by becoming the ruler.

The conquerors themselves disappear, either by being driven out or through rapid amalgamation. Thus the Ostrogoths who gave way eventually before the Huns were in all probability merely the usurping and ruling class, together with their military.

The great Hun invasion which overcame and finally drove out the Ostrogoths, and which was one of the most sustained and serious of the Asiatic invasions of all times, still further obliterated Scythia and disorganized the whole region of the present Ukraina and Bessarabia. Some of the Scythians possibly remained under other names, while others may have receded to Asia; at all events they vanished as a power and entity. They left thousands of kourgans or burial mounds over southern Russia, but probably also, like the Goths, affected in no great way its future population.

The Hun swarm came from beyond the lower Don and Volga. In blood they were of "Tartar" or Ugrian derivation, and partly—perhaps largely—Mongolic.[2] Their language, like that of all the native population east of the Slav Russia, belonged to the Ural-Altaic. From southern Russia they extended their incursions over most of western Europe, reaching finally as far as northern France, where on the Catalaunian plain they met their Marne. Soon after this defeat, in 455, their dread chief Attila died, the power which they established in Pannonia and Central Europe rapidly crumbled, their confederates, among whom were some of the Germans and even Ostrogoths, broke loose, and what remained of the horde, no longer able to hold its ground, retraced their steps eastward beyond the Dnieper and were lost to sight. Exactly what effect the Hun invasion and prolonged occupation had on the population of southern Russia is difficult to gauge, but it was probably more that of destruction and dispersion than blood admixture. Yet remnants of the Huns may have remained in what was once Scythia for a long time after their original name disappeared.

The Scythians, together with the problematical Sauromatae, the Goths, the Huns, and other early groups, became now gradually replaced in southern Russia by a new ethnic unit, the Khazars. The Khazars were, according to many indications, of Caucasus or Asia Minor extraction, and related to the Georgians and Armenians. There were with them, however, also the so-called "Black Khazars," who may have been Huns. Their history in Russia extends over a very considerable period of time—from the end of the second to the eleventh centuries. Between 600 and 950 their territory spread from the Caspian Sea to the Don and later even into Crimea. They were relatively civilized people, who built towns and engaged extensively in sea trade, which earned them the name of the "Phoenicians" or "Venetians" of the Caspian and Black Seas. In the earlier part of the seventh century their power was such that they compelled the agricultural Slavs of the Dnieper and even those of more northern regions to pay tribute. About 740 they accepted Judaism. But during the ninth and tenth centuries they were gradually overwhelmed by the Russians, and in the eleventh century they practically disappeared from the stage. Remnants of the Khazars probably still exist in the Caucasus.

The Khazar occupation of the regions which now form southeastern Russia was, however, far from uniform and continuously peaceful. The waves of invasion of the Turkish and Tartar tribes from farther east followed one another with greater or shorter intervals and over approximately the same roads, the broad open steppes, traversed before by the Huns. Some of these invasions it is not necessary to enumerate in detail. The more important ones were those of the Bolgars, in 482[3], of the Avars in 557, and those of the Polovtsi (Kumans), Ugri (Magyars), Pechenegs, and related tribes, in the ninth and tenth centuries. Whatever the name under which they came, they were, so far as can at present be discerned, all of Tartar or Turkish or Ugro-Finnic extraction, which means mixtures in differing proportions of the white (western Asiatic) and yellow-brown (Tungusic or Mongolic) racial elements. All were more or less nomadic and destructive, bent on spoliation, and on penetration toward the richer more southern and central parts of Europe, rather than on the conquest of Russia and the establishment there of a permanent new home; though some, such as the Polovtsi, Pechenegs, and others, became for a greater or less period settled in Russian territory before they disappeared. Taken collectively, these invasions resulted in a great retardation of the settlement of the southern parts of Russia by the Slav people, as well as in seriously hindering the cultural advance of the Russians; but the hordes did not colonize or mix readily, except through captives, and while some remnants of them and mixtures were doubtless left scattered over the territory, they made no great impression on the eventual Russian population.

[2]It seems almost superfluous to state that racially the Germans have nothing in common with the Huns. The only present European relations of the Huns are the Magyars and Turks, the blood of both of whom, however, is now so much mixed with that of European or Asia Minor populations that the original types are submerged.

[3]These were the non-Slavic Bolgars from the Volga, who eventually left their name to the Slavonic state south of the Danube.

Meanwhile, since as early as the times of Herodotus, we began to hear of tribes such as the "Budini," which reached far eastward in Russia, and may have been Slavonic. In the fourth century, according to Jordanes[4], the historian of the Goths, Hermanric conquered the Veneti, or Vends, which was the earlier generic name for the Slavs, the term "Slav" not appearing even in the Byzantine chronicles until after the close of the fifth century. In Jordanes' time, or about the middle of the sixth century, the "populous race of the Veneti dwell near the left ridge of the Alps (Carpathians) which inclines toward the north and beginning at the source of the Vistula, occupying a great expanse of land. Though their names are now dispersed amid various clans and places, yet they are chiefly called Sclaveni and Antes. The abode of the Sclaveni extends from the city of Noviodunum and the lake called Mursianus to the Danaster, and northward along the Vistula. The Antes, who are the bravest of these peoples dwelling in the curve of the sea of Pontus, spread from the Danaster to the Danaper, rivers that are many days' journey apart." In another part of the work of the same author we read that these new people "though off-shoots from one stock, have now three names, that is, Veneti, Antes and Sclaveni." And "they now rage in war far and wide, in punishment for our (*i. e.*, Goth) sins," though once "all were obedient to Hermanric's commands."

During the ninth and tenth centuries many Slav settlements or outposts are mentioned in Russia as far north already as the Tchoud country (Esthonia), and as far west as the region between the Don and the Volga. Since the sixth and seventh centuries, also, we have historical data indicating extensive and in a large measure solid Slavic population reaching from the Balkans to Pomerania, and from Bohemia and the Elbe over Poland, Galicia and western Russia. This population, the vital center of which seems to have been the territory about and north of the Carpathians, is subdivided into numerous "families," tribes, or nations, which form as yet no great units. The term Slavs (probably from slavit, to praise, to glorify) as applied to these people may possibly have originated from their frequent usage in personal names of the terminal "slav," as in Jaroslav, glorifying the spring, Mstislav, extolling revenge, Boguslav, praising God, etc., which at that time was common to the whole people. Their earlier history and origin were lost in the mists of uncertainty, and their western contingents were not always clearly differentiated from the Germanic tribes. Also, they bore as yet none of those names under which they later became distinguished.

The political unit of Russia did not come into existence until the ninth century. At that time, according to the "Ancient Chronicle" of Nestor, the first Russian historian, there lived in the regions along and west of the Dnieper and farther northward, the following Slav tribes: On the Ilmen, the Novgorodci; on the upper Dnieper, Dvina and Volga, the Krivitchi (who may, however, have been partly of Lithuanian origin); between Dvina and Pripet, the Dregovitci; southeast of these, the Dierevliane (the woodsmen); from Teterev to Kiev, the Poliane (those of the flatlands); on the Bug, the Duliebi and Buzhane; on the Dniester and Bug, the Tivertsi and Ulitchi; in Volhynia, the Volinane; on the Sozha, the Radimitchi; on the Oka, the Viatitchi; and on the Desna and Seim, the Severiane (the northerners).

These tribes or local groups, however, were not yet united, and, acording to Nestor, their dissensions finally led an influential elder to propose that they call some prince of foreign blood, the envoys called on certain princes of the Variags or Varangians of Scandinavian origin. These were three brothers, the oldest of whom was named Rurik. They were offered the privilege of becoming the rulers of the tribes and, accepting, the Slav territories were divided among them; shortly afterward the entire nation became united under Rurik. But in the opinion of some modern Russian historians the real facts were that the Slav and Tchoud tribes, suffering from repeated incursions of the much better armed and trained Scandinavians, hired other "Variags" for their protection and these ended by usurping the ruling power over the tribes. Such was the birth of Russia. The term "Rus" appears at about the same time. It is probably derived from "rusij," fair-haired, blond, and was applied at first to blond non-Slavic elements, but after a time came to be used by foreigners and then by natives for the whole new nation. The Variags played a prolonged but subordinate and steadily diminishing rôle in the Russian annals until they eventually disappeared, leaving little behind except some of their given names such as Oleg, Olga, etc., which are in frequent use among the Russians to this day.

(To be continued.)

[4]Mierow's version, Princeton, 1908.

Packing for Export*

Appropriate Methods Resulted in Saving Tonnage and Wares

By Capt. H. R. Moody, Q.M.C., U.S.A., Chief of Packing Service, U. S. Army

AMERICAN exporters generally for many years have had the reputation of packing goods improperly for overseas shipment. Time and again travellers and investigators in foreign lands have pointed out that if America expected to compete successfully in foreign trade with other manufacturing nations, she must learn to pack goods so that the packages would not break en route and damage the contents. When we sent an army of over 2,000,000 men to France, it was evident that unless we learned quickly how to put up our supplies properly for overseas shipment, our lack of knowledge would be costly to us. Accordingly the Packing Service Branch of the Quartermaster Department was established.

We admit that the many radical changes made in the specifications for boxes, more particularly subsistence supply boxes, have caused a certain amount of hardship to the canners and box manufacturers of the country, but it has been our constant effort at all times to make the changes disturb former conditions as slightly as possible, always keeping in mind that the boxes must be able to stand the stress and strain of not only the overseas shipments, but the extra handlings to which they were subjected after their arrival at the Port of Debarkation. The Forest Products Laboratory at the University of Wisconsin was of great assistance to the Packing Service Branch and to the other packing men of the army in determining the relative strength and resistance powers of the several kinds of wood, and the laboratory at Madison, Wis., was used frequently to determine the tensile strength of strappings, size and quality of nails and all other incidental matters pertaining to the proper manufacture of containers not only for overseas, but also for domestic use.

It was found that in the crating of heavy materials such as machinery, etc., a great deal of space was being wasted, and owing to the great shortage of ship tonnage, every inch of space was invaluable to the service of supply. A special study was therefore made on conservation methods whereby as much waste space as possible would be saved; and the thousands of cubic tons of space that were saved in the various articles shipped is astonishing. I have in mind the particular item of rolling kitchens for which an order of six thousand was placed at one time. The manufacturer of these kitchens submitted a crate for our approval which he purposed to use in packing this merchandise. After careful consideration a new form of crate was devised for this kitchen, which showed a saving in ship space of over 22,000 cubic tons for the 6,000 kitchens. It can readily be seen that this represented a saving of practically four 5,500-ton ships and released this space for the shipment of other necessary supplies oversens.

The same applies to the handling of the 3- and 5-ton motor trucks, thousands of which were shipped for the use of the American Expeditionary Force, and which were most essential items in handling supplies overseas. It was found that the orignal 5-ton Packard truck, completely set up, occupied approximately 1,000 cubic feet. Experiments were therefore started at the Motor Transport Camp at Baltimore to determine how this truck could be dismantled without seriously interfering with its reassembly on the other side, and still pack it in the minimum ship space. After a long series of experiments, it was found that the 5-ton truck could be packed into a crate which would occupy 268 cubic feet; in other words we were able to ship approximately four trucks knocked down, where we originally shipped only one, with the additional factor that the trucks always arrived in good condition. In treating crates, we found it always necessary to stipulate what is commercially known as the three-way corner construction, with the proper application of the diagonal, horizontal and upright members. On heavy crates, skids were always used on the bottom and were slotted so that the slings used to hoist and lower the crate could be set in the slots, thereby preventing any chance of slipping. Another item which we always insisted upon, was marking the crate with white paint to show the center of gravity, and the slots were then placed equally distant from this line so that in lifting the crate it always rode on an even keel. This prevented the possibility of the crate slipping out of the slings, or one corner striking the hatch combing or edge of the dock in handling, and tended to prevent the smashing of the form members of the crate. Wherever an article that contained empty space, such as cauldrons in rolling kitchens, was crated or boxed, the spaces were packed with other supplies such as sacks of beans, rice, sugar, flour, etc., so that every inch of available space was used to get overseas the enormous quantities of supplies necessary to feed and equip the rapidly increasing American Army. At this point I would like to quote from a statement which is issued by the War Department covering the activities of the Quartermaster Corps during the period of the late emergency:

"Now while it was important that Army supplies reach the other side in good condition, it was soon seen that of even greater importance would be the economy that might be effected in shipping space by the scientific packing of goods. This obscure and little known Packing Service Branch was really one of the most important agencies in the whole war organization, since the results which it accomplished in the saving of ship space were nothing short of astonishing. These economies came at a time when the German submarines were still highly destructive to American and Allied shipping, and the shortage of ocean tonnage was one of the most disturbing factors in the whole war situation. The American Packing Service, in saving thousands of tons of shipping space, in reality offset the operations of the U-boat over a considerable period of time."

This shows how important the War Department considers the question of proper export packing and the maximum conservation of space. The War Department is very anxious that the commercial public should have the benefit of all this saving effected during the war period, and it is for that reason that I have been given permission to come to Chicago and lay before you these few simple facts regarding what has been accomplished in the matter of overseas shipments.

When the United States entered the great European War, they at the same time entered what was to become the greatest export business that the world has ever seen, not under the ordinary commercial circumstances, but under the most extraordinary and hazardous conditions possible. Last year there were shipped from this country to the overseas forces over 60 million cases of canned goods, this being merely one item on the Quartermaster's list of 50,000 separate and distinct items.

In no respect did the Packing Service effect greater space economy than in the packing of clothes for the American Expeditionary Force. Formerly clothing had gone forward to troops packed loosely in wooden boxes. The Packing Service devised the system of baling all clothing, and a baling plant was set up at the army supply base in Brooklyn. The Service gave scientific attention to the proper folding of garments and eventually, after exhaustive experiments, developed a system of folding that allowed the maximum number of pieces to a bale. It was found that these new methods saved two-thirds of the space that had been used formerly for the shipment of the same quantity of goods in boxes, to say nothing of the great saving both in labor and boxing materials.

The baling plant at New York in the calendar year of 1918 shipped to France approximately 1,000,000 bales of clothing and textile and other equipment that could be baled. The saving in money to the United States Government by this method of packing at this one plant in a single year amounted to approximately $55,000,000. The largest item in this economy was the matter of cargo space, which is estimated at $49,000,000, saved to the Government. The total financial saving in the shipment of these 1,000,000 bales amounted to $51,678,000 for material, labor, tare weight and cargo space, to which is to be added a saving of $3,670,000 in rent, maintenance, freighting, repacking and unloading, making a grand total of $55,348,000.

In addition to the financial saving there was a large saving in raw materials, which count for more money to a nation engaged in a desperate war. This million bales of clothing saved 58,000,000 board feet of lumber which would have been used in boxing, had the old system of packing been followed. The lumber which would have gone into these boxes requires 30 years for its growth, while the burlap covering the bales was made of jute which is raised in semi-annual crops.

The size of the bale adopted was 30 inches by 15 inches by 14 and up to 19 inches. It is interesting to note that this size was determined upon because it was found that the burlap covering bales of this size would cut into sand bangs with a minimum amount of waste material. The Army abroad used great quantities of sand bags. Thus, by wrapping bales in burlap pieces of proper size, there was saved a considerable amount of cargo space previously occupied by baled burlap which had formerly been shipped to France to be made into sand bangs. It is also notable that baled clothing arived in France in much better condition than clothing which had been packed in cases.

It is impossible for me at this time to go into all of the details of extra packing but this question of proper packing overseas goods is commended to your earnest consideration, as it is believed to be one of the most potent factors in the proper handling of foreign trade. The American manufacturers have been scolded and upbraided for improper export packing but I have noticed that there has been very little constructive criticism—the methods have been found fault with, but no great improvements have been suggested. I, for one, do not believe in this system of general fault-finding, but do believe in constructive criticism; in other words, it is necessary for us to get together, find out what the faults are, and correct them wherever possible. That is the spirit in which I am coming to you to-day, to ask for your co-operation and make the offer which I now do, of co-operating with you in every way possible to improve our packing, so that our merchandise may arrive at the foreign customers' warehouses in as good condition as possible under all circumstances.

This spirit of co-operation which I am counting on has been the keynote of the American nation during the entire war, and without this spirit and the teamwork that this country has shown, it would have been absolutely impossible to accomplish what has been accomplished. Every man present has done his part, either overseas with the Army, with the various supply divisions that were forced to remain on this side of the water to see that the supplies were sent out, or as a private individual, enthusiastically supporting the Government by every word, thought and action; and when the story of this war is written, I firmly believe that one of the most outstanding features will be this marvelous team-work that the American people have shown in the sudden emergency which arose when war was declared. I believe that this spirit is best exemplified by the story which I have told a number of times, and which I am never tired of telling. When the American Army first began taking over some of the smaller sectors on the French front, a number of the French high officers were somewhat dubious as to what the action of the American troops would be, and during an engagement on one of these sectors, the French Commander, being a little anxious, sent a Staff Officer to General Pershing and asked how deep his line was on this particular sector. The General answered that his line extended from "No Man's Land" to San Francisco, which was typical of General Pershing and exemplifies the feeling throughout the Army, of the enthusiastic support of the American people during the war.

It would seem a great pity if we cannot take advantage to the fullest extent of all the lessons learned during the past few years, and I, for one, sincerely hope that the spirit of co-operation and team-work may continue through all our business relations, particularly as to foreign trade.

In the matter of foreign trade, I would like to say a few words concerning what I believe to be of great importance to all those interested in the expansion of our foreign markets, another subject upon which a lesson should be learned from war conditions. Owing to the great number of men of the American Army sustained on the various battlefronts and the enormous quantities of supplies which were necessary to sustain these men, the natives have become acquainted with a great quantity of American made goods, which previous to the war were entirely unknown to them. This is particularly true of canned food, and if this is followed up, I firmly believe that a very big market can be built up for American merchandise. For instance, the average Frenchman had, previous to the war, no conception of what our canned corn was. His idea of corn was the dry yellow kernel, which was ground into corn meal and which was never very popular with the French public. He is now acquainted with the quality and delicacy of our canned sweet corn and from talks that I have had with many officers who have returned from abroad, I believe that a very big market can be built up, not only in canned foods, but in many other items of goods manufactured in this country. It would seem that the proper method in going after this foreign

*Address before Sixth National Foreign Trade Convention, Chicago, April 29, 1919.

trade which is open to us at the present time, would be to co-operate and consolidate competing lines for foreign trade so as to reduce foreign competition in American-made articles to a minimum. This appears to be the only way in which a big success can be made and it is surely hoped that the American manufacturers will continue to take advantage of the present laws to form these associations. It is very apparent that co-ordination of effort continues to make for success. It was the co-ordination of effort and the consolidation of not only the entire American Army, but the entire Allied Army as a unit, that spelled success for the Allied Countries.

I therefore commend to your attention the ultimate co-operation of effort that is possible under proper business principles.

Some Zinc and Aluminum Alloys*

By Walter J. May

THE necessity for the conservation of heat in melting and also to some extent the use of cheaper forms of metal than aluminium or brass, make some form of substitution often desirable, and where this is the case the alloys mentioned below come in very handily, as all melt at below 1,000° F., or just as redness is produced, this making it possible to melt the alloys over the open fire in iron ladles. Of course, where copper is used the heat required in making an alloy of copper and zinc or aluminium in the first place is large, but by making an alloy of 75 per cent. Zn or Al and 25 per cent. Cu in the first place, and running into conveniently sized bars, open-fire alloying can afterwards be done at a comparatively low temperature, thus making the work simple enough as a rule. As a general thing, however, melting in crucibles has advantages over open-fire work, and as good plumbago crucibles have a long life, it is probably more advantageous to use them for general work. Clay pots are not of any great use, as they break too quickly; and although the first cost is small, the expenditure over a fairly long period is usually higher than with the plumbago article.

Given the copper alloy just mentioned, it is easy to make the other alloys, because zinc melts at about 775° F. and aluminium at about 1,300° F., the zinc being fluid long before red heat is reached; aluminium fuses at a dull red, and the alloy at a trifle above the fusing point of either, according to which is used, and as the alloy holds a quarter-pound of copper for each pound of its weight, it is easy to calculate proportions, and as an instance, if we are making up a Zn-Cu mixture, holding 8 per cent. copper, we should simply melt 68 per cent. plain zinc and 32 per cent. of the alloy together to secure the required content.

Where no great heat has to be resisted and where there is no percussive action on the metal, zinc stands well for many purposes where brass is more generally put in, and being cheaper than brass in ordinary times, it can very well be substituted, the only objection being the way in which it crystallises during cooling unless broken down with at least 5 per cent. of copper, this producing a "grain" very similar to that of cast iron. The resistance to compression is considerable, and the alloy runs up as sharp as can be desired where good moulding is used, ornamental work being very often produced in zinc in its pure or alloyed state. A large number of the cheap "bronze" ornaments are simply zinc or a zinc-copper alloy, and these when hollow are produced by "slush" casting, in either plaster or metal moulds, the finish being given by copper-plating in neutral baths and then bronzing. This is mentioned to show what the alloy can be used for, and as casting can be practically continuous, the work is done cheaply on the labor side of the total outlay. Generally, the zinc alloy ranges from 95 to 92 per cent. zinc and from 5 to 8 per cent. copper, with occasionally up to 1 per cent. lead, and probably as an accidental admixture 1 per cent. of iron, neither of these having much effect on the general behavior of the metal.

Having occasion to use a whiter alloy than that given above, the writer at one time used a mixture holding aluminium, and eventually the following series were put into use, the last two being used for cheap bells, as they produced a pleasing tone while requiring the minimum of lathe-work to leave them in a highly polished state, a thin coat of transparent lacquer being used to prevent oxidisation.

	No. 1.	No. 2.	No. 3.	No. 4.
	%	%	%	%
Zinc	89	88	83	77.75
Copper	9.75	9.75	14.75	20.0
Aluminium	1.25	1.25	1.25	1.25
Tin	—	1.0	1.0	1.0

The two last were also used for cheap bearings in some domestic machines, being paired and lightly skimmed out to leave a bright surface, and when finished cost about half what brass would have done. When turned up these zinc alloys had a steely appearance and were harder than brass, this making them suitable for the purposes to which they were put. The melting point was low, and when casting was done the bars of the previously made alloy were broken up and melted in iron ladles in such lots as were needed, red heat not being reached, but the exact temperature was never determined.

With simple aluminium-zinc alloys for definite purposes in connection with some light-weight machines, to take the place of cast iron, an alloy of 66.66 per cent. Al and 33.33 per cent. Zn was used with considerable effect, this having a sp.gr. of about 3.8, and melting somewhere around 800° F., some small variations being caused by variations in the purity of the metals. To take the place of cast steel an alloy of 75 per cent. Al and 25 per cent. Zn was used, this having a sp.gr. of about 3.4, and melting at somewhere about 850° F.; but again variations occurred. These were very carefully made crucible alloys poured as soon as made without remelting, and the machines in which they were used had no heat to withstand. At the then cost of metal these alloys cost under 10d. per lb., and compared with cast iron the weight was approximately half, although the castings did not follow on the same ratio of price. Assuming that these alloys were made and cast into bars, they could very well be remelted in open ladles, as the melting point is low enough, but necessarily remelting causes some loss, as all these Al-Zn alloys absorb oxygen freely when they are heated.

In making aluminium-zinc alloys for toughness, and to enable them to be drawn into wire, or the like, with freedom, not more than 15 per cent. of zinc must be used in their manufacture, while 10 per cent. would give appreciably better results; but cost necessarily has to be considered, and probably the largest amount of zinc possible would be used consistent with obtaining satisfactory results. For making such things as cycle tubes 65 per cent. aluminium, 30 per cent. zinc, 4 per cent. copper, and 1 per cent. tin, or some approximately close alloy, has been recommended, this being asserted to be as strong as steel for the purpose, and being roughly half the weight. The cost would not be prohibitive, as at the present prices of metal ingots for drawing should be produced at about 11d. to 1s. per lb., possibly in some cases less, as variations in buying take place; but any way the cost is not excessive. This is a crucible alloy, which has to be made with some care, but a Cu Zn alloy can be used for adding the copper, and so reducing heat requirements.

There are also other alloys in which aluminium or zinc form important part of the content, such as magnalium, duralumin, wolframinium, meteorite, and the like, and in these special qualities are secured, but they require special skill in alloying to obtain the maximum effect, this taking them outside the usual range of work done in the non-ferrous foundry, and often leading to trouble where they are unsuccessfully dealt with. Like making ferro-aluminium, some other alloys require special conditions in working, and, failing these, although some sort of an alloy is produced, it is not the thing required, and is usually deficient in the special qualities which make the well-made alloy of some particular importance. Simple alloys in which the metals readily combine can be made by anyone; but complex alloys which need particluar conditions in the making to ensure success are scarcely the things which the ordinary foundryman can deal with, although after they are made in very many cases he can very successfully remelt and cast them. This is important to remember, because when working with expensive metals there is no chance of making good when serious losses are made by irregular working, in the same way as can be done with iron and other low-priced things, badly made complex alloys having practically no value as scrap.

*From *English Mechanic and World of Science.*

The Oxidation of Ammonia

By J. R. Partington

THE present communication is based upon a lecture which was given on four occasions at the British Scientific Products Exhibition, held at King's College, London, during the period August 12—September 7, 1918, by the members of the staff of the Nitrates Section of the Munitions Inventions Department Research Laboratory. A demonstration of an ammonia oxidation apparatus in operation was given at each lecture.

The vital importance of providing a national supply of combined nitrogen for munitions and agricultural purposes requires no elaboration in this journal. Something has been heard of the successful exploitation of nitrogen fixation processes in Germany, but of the progress made in the Allied countries, little information has been published. In England, the Munitions Inventions Department of the Ministry of Munitions has been actively engaged in research connected with this problem and its reports have met with a large measure of success.

One of the first problems investigated was the oxidation of ammonia with atmospheric oxygen, a reaction which has long been known to occur when ammonia gas and air are passed over a heated catalyst, such as platinum. The plant required for carrying this into effect is very simple in principle.

One form of technical converter unit is shown in the illustration. It consists of a top and bottom cone, with three rectangular body pieces between them, all in cast aluminium 1/5 in. thick, the rectangular area exposed measuring 4 in. by 6 in. The pieces are provided with flanges, ¾ in. wide, to facilitate bolting together, and three perforated baffles are inserted in all the junctions except that between the top cone and the top segment of the body, which is occupied by the catalyst frame. Though each cone possesses a sight orifice, 1½ ins. in diameter, for reasons of standardisation, that in the top cone alone is used, and is provided with a mica window for inspection of the catalyst. Aluminium bends of 2 ins. internal bore provide inlets and outlets for the mixture of air and ammonia at the bottom, and the oxides of nitrogen at the top, respectively. The overall length of the converter is about 4 ft. and its weight is about 32 lb.

The air supply is obtained from a blower, and it is essential that the air and ammonia should be well mixed. If ammonia gas is used, it may be injected into the air stream through a nozzle, after both gases have been measured. In technical practice it is more convenient to use purified ammonia liquor containing 25 per cent. of ammonia, which is now a commercial article. The air is passed, together with a small amount of steam, into the base of a coke tower down which this liquor flows. The mixed gases are cooled in the upper portion of the tower, where the steam is condensed. The mixture of air and ammonia should be filtered, either by passage through a length of coke packing in the under portion of the tower or through a filter packed with glass wool, which removes particles of dust. Oxide of iron particularly must be eliminated, as this has a deleterious effect on the platinum catalyst.

The most important part of the apparatus is the catalyst, which is fixed between the upper cone and body segment. It consists of one or more gauzes made of pure platinum wire, stretched across the converter at right angles to the gas flow. The wire used is 0.0025 in. diameter, and is woven into gauze with 80 meshes to the inch. The gauzes are mounted in an aluminium frame. The reaction occurs during the very small interval of time in which the gases are in contact with the catalyst, and is represented by the equation:

$$4NH_3 + 5O_2 = 4NO + 6H_2O + 220 \text{ kg. cal.}$$

The operation of the catalyst must be initiated by heating the gauze, either by means of a nonluminous gas flame, or by heating electrically with suitable current conducted through leads attached to the opposite edges of the gauze. When the first method is used an orifice is provided in the upper body segment just below the gauze, which admits of the introduction of the flame, and is closed when the converter is in operation. The converter figured is provided with leads for electric current. When the reaction begins, the gauze is maintained at a red heat by the heat of oxidation, and the conversion proceeds uninterruptedly as long as the supply of air and ammonia is maintained. The platinum gauze may be used for about three months, after which it is desirable to replace it by a new gauze and to clean and refit. New gauzes are not very active at first, but acquire their full catalytic activity after a few hours' running.

The proportion of ammonia oxidised to nitric oxide is of primary importance from an economic point of view, and the conditions enabling the best yield to be obtained have received a great deal of study. The yield is influenced by a variety of circumstances.

Firstly, it is found that the addition of one or more gauzes to the first one, placed in close proximity to it, has a beneficial influence. In the electrically heated type of apparatus the catalyst consists of two superimposed gauzes, insulated from each other, the lower one of which is provided with leads for electric current. When no electrical heating is used, two or more gauzes can be placed close together to form a composite catalyst in the manner described by Kaiser in 1910. As an illustration of the effect of using more than one gauze, it may be stated that, if a single gauze is used and no heat is supplied beyond that generated in the chemical reaction, then 90 per cent. of the ammonia is recoverable as oxides of nitrogen with a flow rate not exceeding the production of 0.25 ton HNO_3 per sq. ft. of catalytic area per 24 hours. With two gauzes under the same conditions this may be raised to 0.35 ton with the same efficiency, or to 1.5 tons with an

efficiency of 85 per cent. With four gauzes the production attains 2 tons HNO_3 with an efficiency of about 85 per cent.

Secondly, although these figures show that there is a decrease of efficiency when the flow rate is increased, with a converter working without any source of heating beyond that supplied by the reaction, yet it has been found that the efficiency may be maintained at high flow rates by the application of additional heat. This heat is supplied either by electrical heating of the gauze, or by heating the mixture of air and ammonia, or the air alone, to about 350° C. before it reaches the converter.

Thirdly, although the efficiency depends somewhat on the proportion of air and ammonia, yet this can be varied within certain limits without affecting the yield. These limits extend from the proportion requisite to produce N_2O_3 and that leadng to the production of N_2O_5. The best proportion appears to be in the neighborhood of the mixture for N_2O_3, when the gauze has a temperature of 650°—700°. If too rich a mixture is used the gauze becomes too hot, and decomposition into elementary nitrogen results. If too poor a mixture is used, the gauze is too cool, some ammonia passes through unoxidised, and loss again occurs. Within the limits referred to the yield is only slightly influenced by the temperature.[1]

Under established conditions, an output of 1.5 tons of nitric acid (HNO_3) per square foot of catalyst area per 24 hours, with an efficiency of 95 per cent., has regularly been attained. Without the application of external sources of heat, the efficiency, as mentioned, is of the order of 85 per cent. The output of a converter may, however, be reduced to 25 per cent. of the maximum rate without affecting the efficiency.

The platinum gauze employed weighs about 50 grams per square foot and the output of nitric acid per 24 hours per gram of platinum when two gauzes are used thus amounts to 15 kgm. The output of these converters, whether it be referred to their size or to the weight of platinum used, therefore far exceeds that attained in other types.

The hot gases, leaving the converter at about 400°—600° C., may now pass to a cooler, made of acid resisting material, where their temperature is reduced to about 30° C. Additional air may then be added to enable the nitric oxide to pass into nitrogen dioxide (NO_2). The steam produced in the reaction in the converter is also condensed, and when the cooler is very efficient the water formed should carry down only a small fraction of the oxides of nitrogen.

The conversion of ammonia to oxides of nitrogen is a matter of no great difficulty once the conditions are understood. The utilisation of these oxides of nitrogen is, however an intricate problem, the solution of which depends of course on the final product which is desired. A considerable amount of research has been devoted to this side of the problem.

There is, however, one interesting manner in which the oxides can be utilised directly, and this consists in admitting them to the lead chambers of a sulphuric acid installation as a substitute for the oxides of nitrogen obtained by "potting" nitre. The import of this salt, which amounted before the war to 18,000 tons per annum for this purpose, is thus economised.

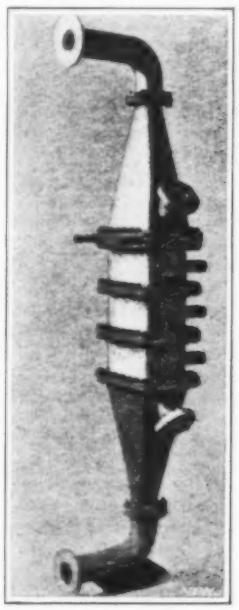
The ammonia oxidation process has already been adopted by several of the large sulphuric works in England, and undoubtedly has a very extensive future before it in this direction. There is a considerable saving of expense in the replacement of nitre by ammonia oxidation, in addition to the much more regular working of the process. A detailed scheme of standardisation of plant has been arranged by a committee on which the Ministry of Munitions and manufacturers are represented, and an efficient form of apparatus devised, including the plant for generating ammonia gas from ammonia liquor.

By reason of the high productive capacity of the new converters, a unit of only 2 by 3 inch cross-section, which was shown in operation at the exhibition, is capable of supplying oxides of nitrogen to a chamber plant of moderate capacity, and has been used for that purpose. The standardised design has a cross-section of 4 by 6 inches and will supply an efficient chamber plant making 80 tons of acid per day.

If the oxides of nitrogen are not utilised directly they may be converted into nitric acid by absorption in water. This necessitates a system of absorption towers such as is used in the arc process. Since, however, the gas from the ammonia oxidation contains about 10 per cent. by volume of oxides of nitrogen as compared with 1 per cent. in the gas from the arc, the size of the tower system can be reduced, but even so the cost of the towers alone comprises about half the cost of a complete installation for making dilute nitric acid of about 550 per cent. strength from ammonia.

When this dilute acid is obtained it may be neutralised with a further quantity of ammonia to produce ammonium nitrate, or by soda or limestone to produce fertilising materials.

Many other ways of utilising the oxides of nitrogen are being investigated, so that the British nitrogen industry may be in a favorable position to fight that of Germany in the time of keen competition which is coming. Ammonia oxidation plants are also in operation in the United States, in France, Italy and Russia. This country does not yet possess a national synthetic nitrogen works, and in this respect it compares unfavorably



with several other countries. The importance of this new industry may be gauged from the recent statement of Mr. Secretary Daniels, of the United States Government, that he considers the nitrate situation as one of the most important and critical of the whole war, and that his Government has allocated no less than £20,000,000 for the erection of five large works for the production of nitric acid by the oxidation of ammonia.

[1] On the influence of temperature and composition on the yield, compare Partington, "The Alkali Industry" (1918).

Recent Developments in Marine Lighting

(*Continued from page 359*)

surrounding the mast were introduced, but lanterns are now generally placed on the top of the mast.

A typical example of attended lightship is that at Newchwang, China, the apparatus for which embraces several novel features, one of the most important of which is the arrangement of the pendulum. The latter contains the air and oil receiver for the incandescent burner, the air being supplied at a pressure of 65 lb. per square inch, by means of a pipe carried up inside the tower, or, alternatively, by means of a hand-operated pump inside the lantern. The incandescent burner carries a mantle of 35 mm. diameter. The gimbal carriage and lantern have been designed to allow a movement of the pendulum of 45 degrees on either side of the vertical; this being, it is stated, the greatest movement which has ever been allowed in an apparatus of this kind. The optical apparatus is of the fourth order, size 250 mm. focal distance, and gives a triple flashing characteristic. It comprises four panels of refracting and reflecting prisms, each subtending a horizontal angle of 99 degrees. The appliance gives two flashes in quick succession every 10 sec., viz., a flash of 0.44 sec., eclipse 1.5 sec., flash 0.44 sec., eclipse 7.6 sec. The intensity of the beam is estimated at 28,000 British candle-power. The lenses are supported by a cast iron table carried by the gimbal ball bearings, which itself are carried by means of a ball bearing carriage fitted with horizontal and vertical rollers, all with ball bearings. A further set of ball bearing rollers is placed under the carriage so as to prevent the possibility of the apparatus lifting. The top table of the carriage is provided with a gun-metal race wheel, which is actuated by means of a bevel pinion in connection with horizontal and vertical shafts driven by clockwork mechanism, the latter being operated by a falling weight, and steel wire rope guided in vertical ways in the tower. The clock is placed upon the floor of the lantern. All the main shafts of the clockwork mechanism are provided with journal and double thrust ball bearings. The barrel shaft is of steel, and the clock winding gear is so arranged that it can be operated inside the lantern or at the bottom of the tower. If necessary, the apparatus can always be rotated by hand from inside the lantern and from the deck. When not at work or being cleaned, locking gear, consisting of three stays which fit into sockets on the pendulum casing, is used. One of these stays is adjustable in length by means of a screw coupling. A further set of locking gear is provided between the top of the revolving carriage and the table which carries the lenses.

A similar installation, but with an apparatus of 375 mm. focal distance, is installed at the Bar Lightship in the Mersey. It has a candle power of 36,000 and is the most powerful lightship on the British coast. The light from it may be compared with the beam from a fixed apparatus of 375 mm., with a nine-jet burner of 315 candle power, which would be about 5,000 candle power. The intensity of the revolving copper silvered parabolic reflector lights, with oil wick burners, is about 12,000 candles. This type of attended lightship apparatus has been almost universal up to the present, but is being superseded by the dioptric type.

(*To be continued.*)

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